The Royal Aeronautical Society

(FOUNDED 1866)

with which is incorporated The Institution of Aeronautical Engineers

No. 226. OCTOBER, 1929. Vol. XXXIII.

PROCEEDINGS

EIGHTH MEETING, SECOND HALF, 64TH SESSION

In the Chair:

THE PRESIDENT, COLONEL THE MASTER OF SEMPILL

The eighth meeting of the second half of the 1928-29 Session was held at the Royal Society of Arts, London, on Thursday, April 11th, 1929.

THE PRESIDENT: M. Lapresle was very well known not only in France but in other countries in connection with his aeronautical work. In 1906 he was studying in Paris, where he came into contact with M. Eiffel, and assisted him in the foundation of the first aero-dynamical laboratory in France in the Champs de Mars in 1909-1911, and subsequently, in 1912, at Autueil. At the commencement of the War M. Lapresle gave up his work in the Eiffel Laboratory and joined the infantry. He was wounded in the War quite early, and was captured by the Germans and held prisoner for most of the War period. After his release in 1918 he was given direction of the Laboratory by M. Eiffel in 1919, and retained that post when the Laboratory was transferred to the Government. At the same time he was made Engineer of the 1st Class in the new Corps of Aeronautical Engineers, which was formed in 1925. Since the re-organisation of aeronautics in France M. Lapresle had become Chief of the Service for Aeronautical Research at Issy les Moulineaux, whilst retaining also the direction of the Eiffel Laboratory. It was part of the condition in M. Eiffel's will that M. Lapresle should remain in charge of this Laboratory so long as the Laboratory should be made use of. It would be unnecessary, said the President, to say very much in referring to the work of M. Eiffel, because it was well known to most of those present. There was one thing to which he wished to call special attention. M. Lapresle's paper paid a very fine tribute to people in this country, and in particular to Sir H. Stanton's paper given not so long ago on "The Resistance of Plane Surfaces in a Uniform Current of Air" before the Institution of Civil Engineers. M. Lapresle also referred to work done by other people, and anyone reading the paper might almost come to the conclusion that M. Lapresle himself had not done anything, but had merely followed up the efforts of others. That, however, one knew full well not to be the case, and it was the fact that many of the interesting things mentioned in the paper had been the result of M. Lapresle's own activity and work. As M. Lapresle spoke little English the paper would be read on his behalf by Major A. R. Low, a member of Council, who had translated the lecture from the original French.

FRENCH WIND TUNNEL METHODS

BY

MONSIEUR A. LAPRESLE
Director of the "Eiffel Laboratory," Aeronautical Engineer, Dr. of Science

MR. CHAIRMAN, LADIES AND GENTLEMEN,

I greatly appreciated the invitation of the Society to lecture on the research work of the Eiffel Laboratory and hastened to accept it on account of my early collaboration with M. Eiffel, which led to the setting up of the laboratories at the Champ de Mars and at Auteuil. Since these early days, now distant,

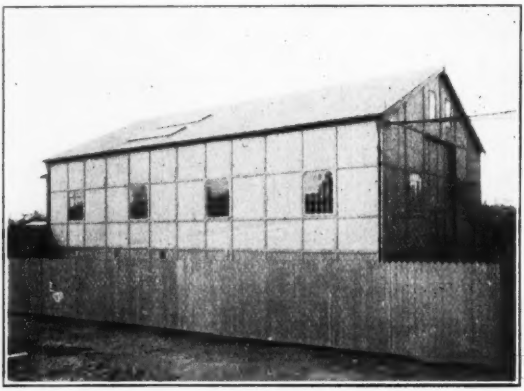


FIG. 1.
Exterior of the modest Champs de Mars laboratory.

I have always kept in mind two papers which first suggested the possibilities of experimental aerodynamics—"Experimental researches carried out at the Eiffel Tower" by Eiffel, and "On the resistance of plane surfaces in a uniform current of air," a remarkable communication to the Institution of Civil Engineers by your eminent countryman, Dr. Stanton, which contains the germ of much subsequent wind channel research. It gives me pleasure to make this acknowledgment before proceeding to read the paper.

Up to 1921 Eiffel was actually occupied in the working of his laboratory, although he had entrusted the technical direction to M. Margoulis during the war, an arrangement which came to an end in 1919. In the beginning of 1921, Eiffel, then 89 years old, leased his laboratory to the "Service Technique de l'Aeronautique Francaise," and designated the present speaker as director. For the time being it is a State laboratory under control of the Service Technique.

In reviewing briefly the role of Eiffel's laboratories in France it may be stated that, although the interest is now largely historical yet no really new principle has appeared to upset his technique of wind channel measurement.

Detail improvements have appeared step by step, such as the mutual interference of model and support, and have been adapted without difficulty to the

aerodynamical balance. The diameter of the working part of the airstream—2 m.— the normal wind velocity during tests—30 m./sec.—are of the order of the most recent foreign figures; and the majority of tests for French constructors of aeroplanes had been carried out in this channel, so far to the satisfaction of the most immediate needs of aeronautical engineers.

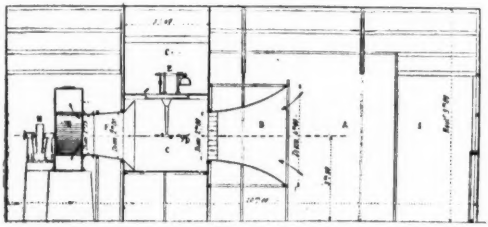


FIG. 2.

Section of the channel with a closed test chamber traversed by a free stream which remains approximately cylindrical—the first application of this principle. Diameter of stream 1.50 m., maximum air speed 15 m./sec.

Of course channels of larger diameter and higher wind speed, furnishing figures more nearly applicable to full size work, should be built and operated, but channels of such a size, 2 m. diameter, and with wind speeds of 30-40 m./sec., will long remain the most convenient by reason of their small cost, and their ability to bring out the salient points in a new problem.

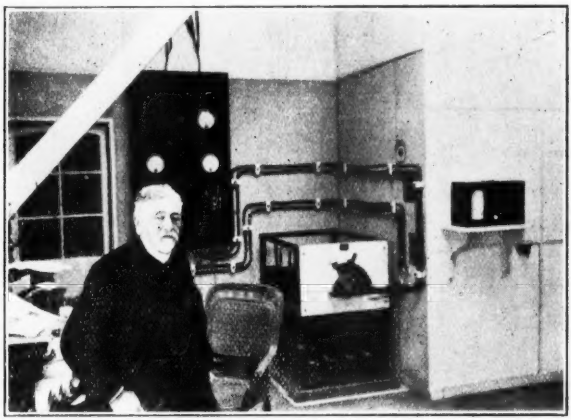


FIG. 3.

M. Eiffel beside the switchboard controlling the installation.

Before proceeding to discuss two questions with which we have been much occupied of late years, the aerodynamical stability of an aeroplane and the velocity field round a wing profile, it is of interest to give a rapid description of the extremely simple scheme of measurement used.

A laboratory of modest dimensions was built at the Champ de Mars, Paris, in 1908, in collaboration with the late M. Leon Rith, an engineer well known in technical aeronautics, to whom we owe the introduction of logarithmic

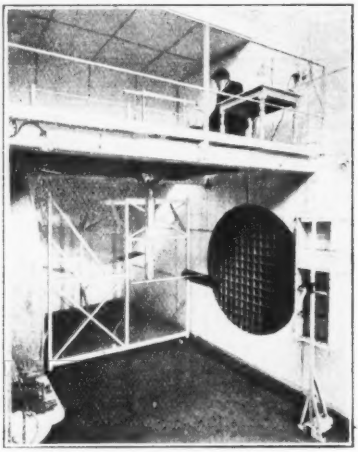


FIG. 4.

Closed test chamber and platform above the free stream carrying the aerodynamical balance, with M. Rith making a measurement.

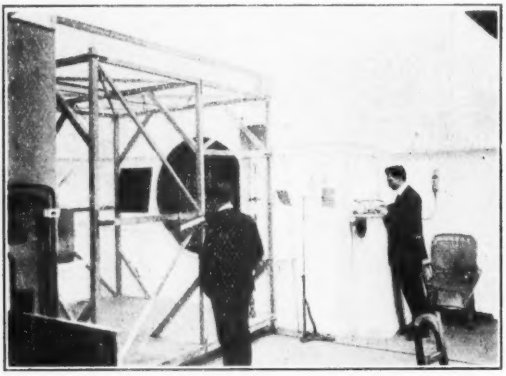


FIG. 5.

M. Rith and the present speaker measuring local pressures.

diagrams, and who collaborated with Eiffel in his early experiments on the resistance of air by arranging the fall of various bodies, guided by a vertical cable 120 m. long. His name should be associated with Eiffel's in the history of aeronautical development. This was superseded by the Eiffel laboratory at Auteuil, early in 1912.

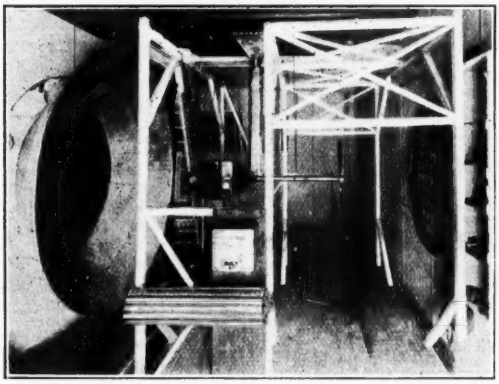


FIG. 6.
The first airscrew test apparatus with 1 h.p. motor.

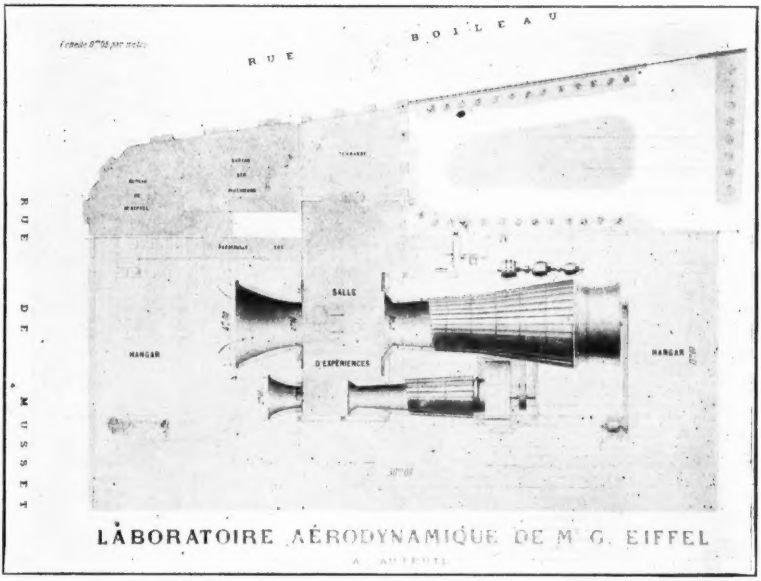


FIG. 7.
Plan view of the Auteuil laboratory, with a long slightly divergent channel leading from the test chamber to the suction fan, a method which economises two-thirds of the power required for a given air speed. The principle, first employed here, is now universally adopted. The two channels in parallel can be used alternately. The larger with a free stream of 2 m. diameter and maximum air speed of 34 m./sec. in the test chamber is used for routine work. The smaller has a free stream of 1 m. diameter and a maximum air speed of 45 m./sec. Both have 60 h.p. motors driving the fans.

These photographs illustrate the more important and interesting applications. It is unnecessary to dwell on the results obtained as these are known to all interested. But in recent years new types of apparatus have been added which merit more detailed description.

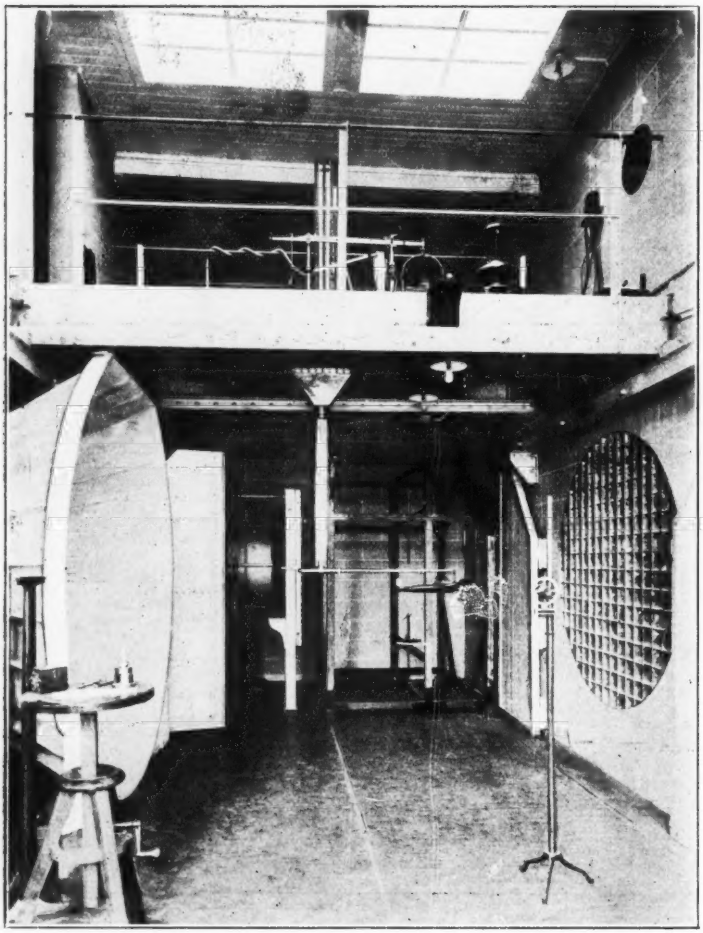


FIG. 8.

The test chamber as equipped in 1912, *the upper platform carrying the aerodynamical balance, the instruments and a* 15 *h.p. motor for airscrew tests.*

A model monoplane is shown under test, attached by two small brackets in the upper surface to the arm of the balance, as employed by M. Eiffel. It was realised in January, 1921, *that this method of attachment was defective.*

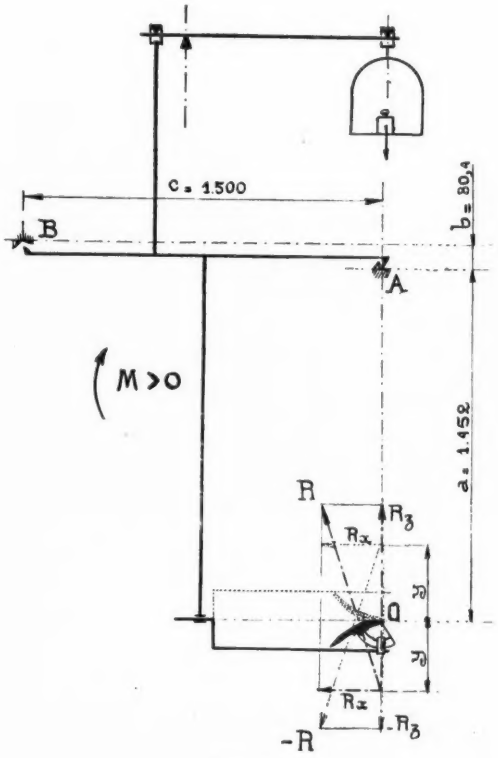


FIG. 9.
Diagrammatic arrangement of the articulation of the balance in actual use.

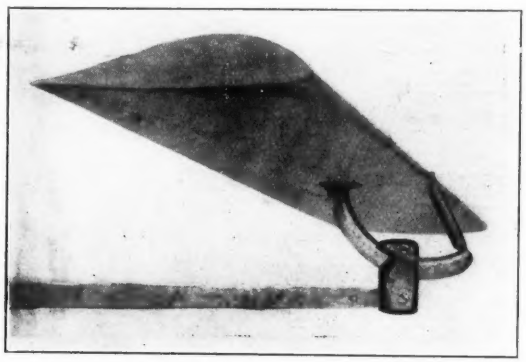


FIG. 10.
Mounting of a wing profile.

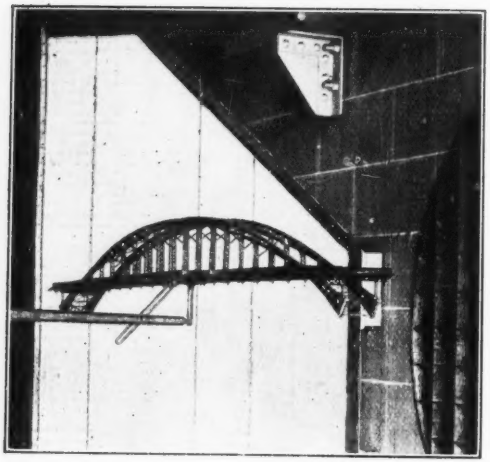


FIG. 11.
Model bridge.

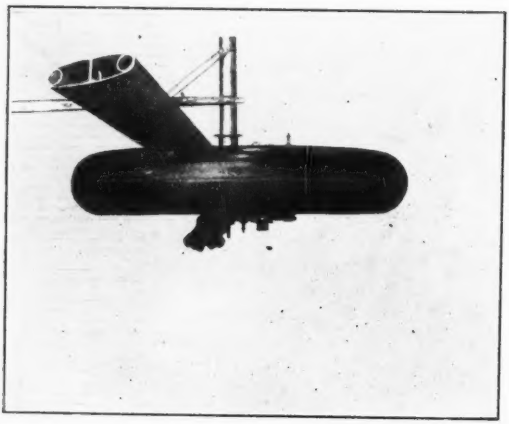


FIG. 12.
Aeroplane wheel.

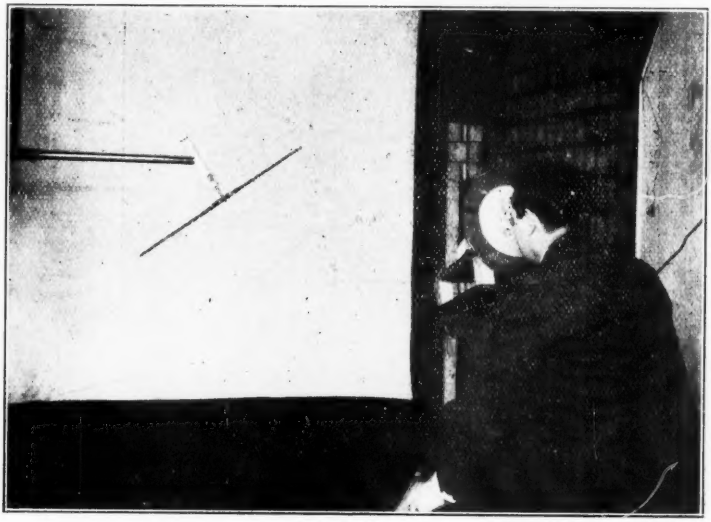


FIG. 13.
Monoplane autogyro.

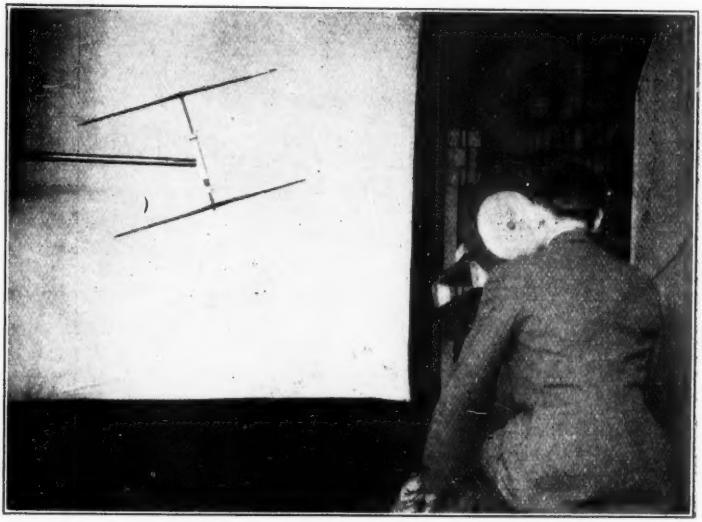


FIG. 14.
***Biplane** autogyro consisting of two superposed airscrews.*

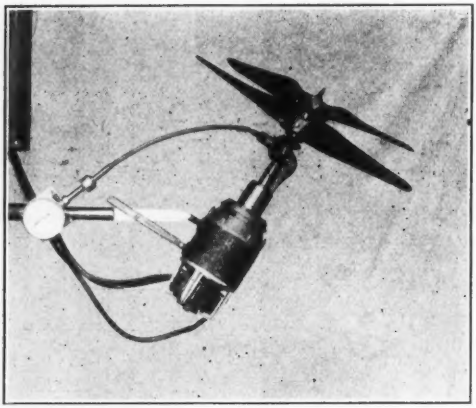


FIG. 15.

Two airscrews of 0.60 m. diameter rotating in opposite directions and inclinable to the wind at any angle.

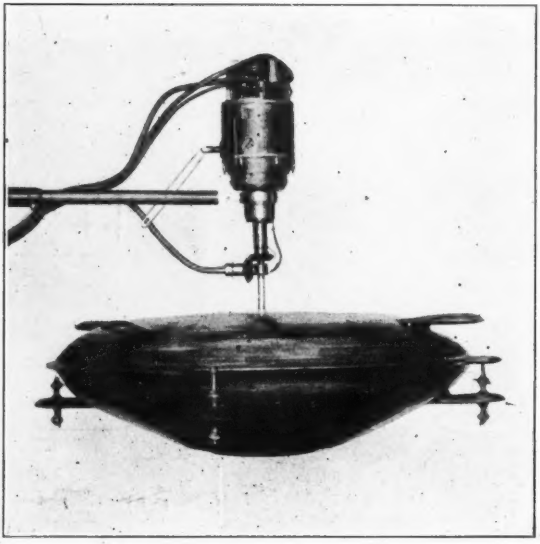


FIG. 16.

Rotating lenticular body with projecting vanes, driven by an electric motor.

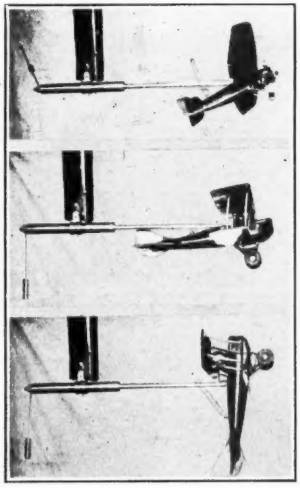


FIG. 17.
Mounting of model aeroplane for experiments on auto-rotation. The horizontal arm is mounted on two ball bearings. An adjustable link controls the incidence.

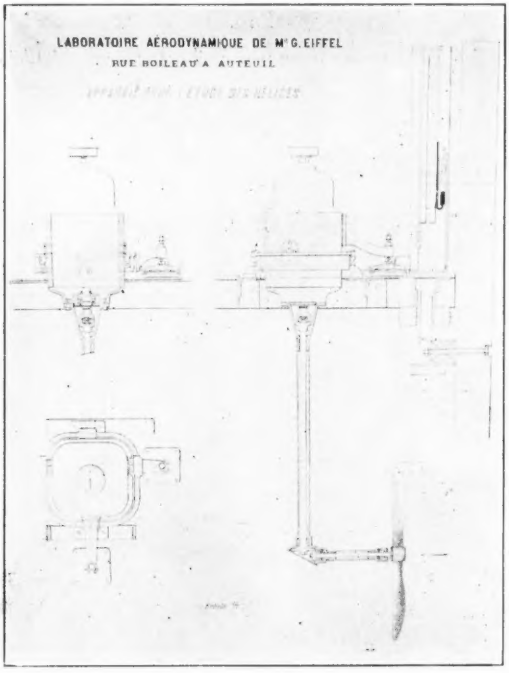


FIG. 18.
Section of the mounting and drive of airscrews under test, with diameters up to 1.20 m.

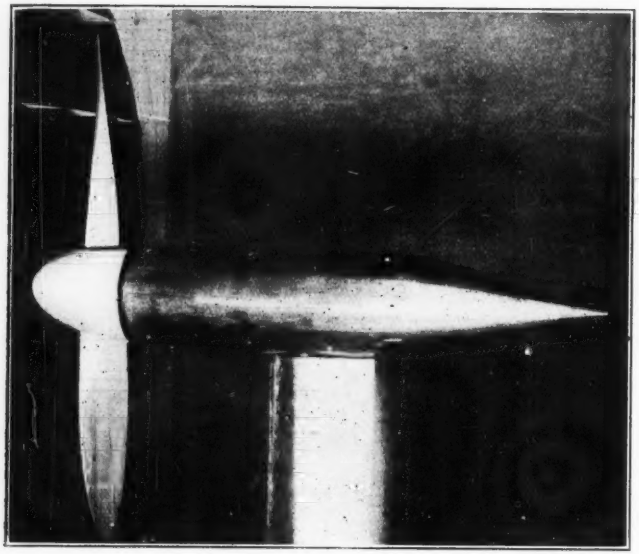


FIG. 19.
Airscrew cowled in front and with a streamline body aft.

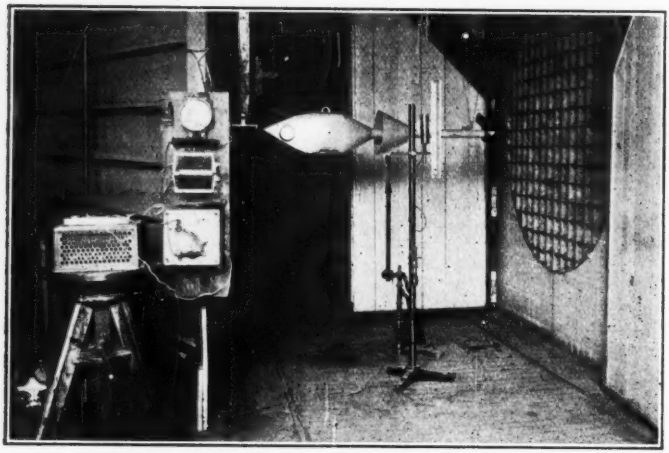


FIG. 20.
Windmill mounted for test.

Pivot Mounting for Test of Aerodynamical Stability

The apparatus constructed for tests of aerodynamical stability has the advantage of giving direct readings of the aerodynamical moments about the centre of mass of the aeroplane, the corresponding point in the model lying on the axis, and the position of the centre of mass off the model itself not affecting the result.

The principle is derived from the old pivot mounting used in early determination of centre of pressure, but the application is quite different.

Pitching Stability

In the investigation of pitching stability the model is mounted on pivots as in Fig. 21.

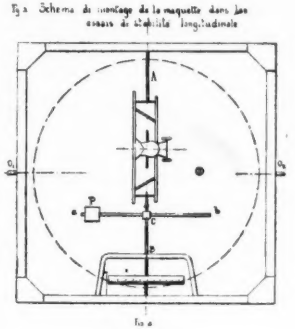


FIG. 21.

The model tends to set itself at its angle of equilibrium, and the lower part of the axis, mounted at B and carrying a divided circle outside the limits of the airstream, measures the angular displacement. On the upper part of the axis B is mounted a rectangular bar (ab) carrying a small plate P adjustable at right angles to the wind and slideable along ab. For each setting of the plate P the system aeroplane-plate takes up a position of equilibrium practically independent of the wind speed, in which the aerodynamical moments of plate and model balance each other. The mounting C of the cross bar ab is held in place by friction only, and can be turned about the axis B until the plate is approximately normal to the wind. The new incidence of the model is very close to the old incidence since the moment of the plate varies very slightly within a range of $\pm 20°$ from a position normal to the wind. This moment is known by previous calibration from which the moment of the model, equal and opposite, is obtained. By moving the plate along the transverse bar a series of readings is obtained which can be plotted at once, and give the pitching moments as a function of the incidence.

Positions of stable equilibrium are observed without difficulty; for unstable positions there is a noticeable tendency for the plate to move in one direction or the other for slight displacement to one side or the other from the position of equilibrium. In passing through such a position the divided circle is moved by hand and the position of unstable equilibrium is observed by touch with remarkable precision. The angles can be read to $\frac{1}{2}$ or $\frac{1}{4}$ degree.

The whole system, axis A and B, model, divided head, etc., is carried in a rectangular frame pivoting at O_1 O_2. The axis AB can be set at any desired angle (angle of yaw), and the pitching stability can be determined

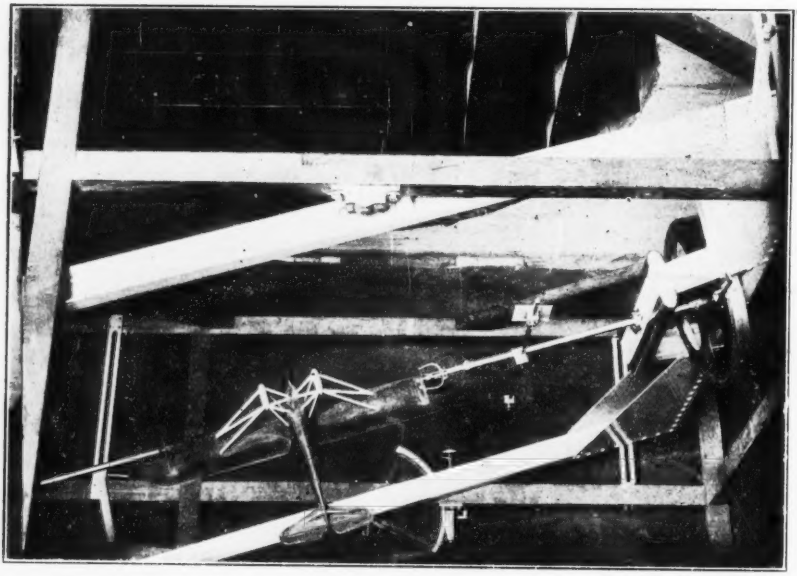


FIG. 22 (RIGHT).

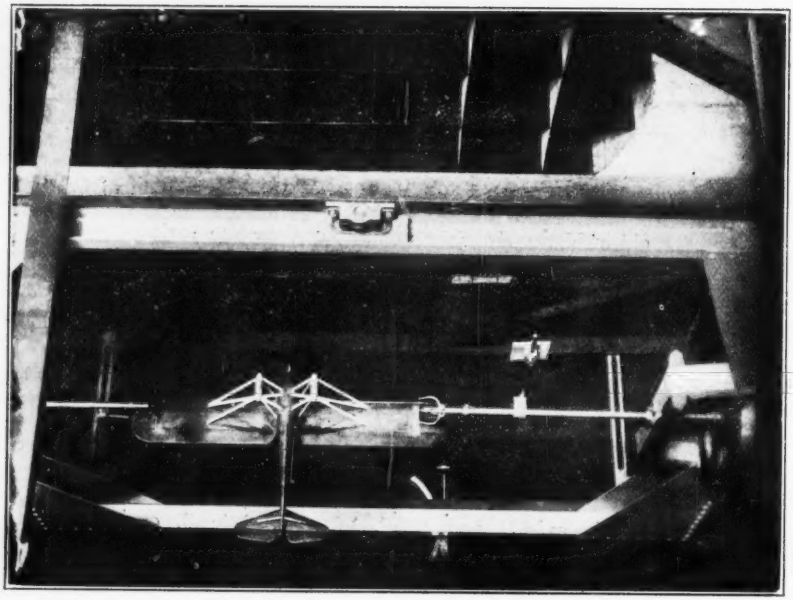


FIG. 22 (LEFT).

for each angle of yaw. The model is then balanced so as to bring the centre of mass on to the axis AB. By the use of two plates of equal weights but of different resistance symmetrically spaced with respect to the axis AB the aerodynamical moments are obtained free from the disturbance of gravitational moments.

Fig. 22 shows the mounting for pitching stability with and without yaw.

Fig. 23 shows a three-pronged fork used to mount the model on the arm B, the three points of which engage in three holes pierced in the supporting plate fixed to each end of the model wing (Figs. 23B-23E).

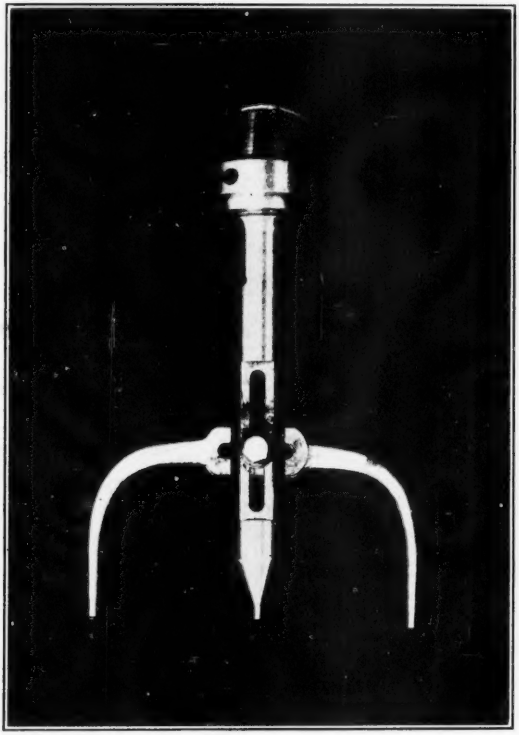


FIG. 23A.

Direction Stability

Fig. 24 shows diagrammatically the mounting of the model for the measurement of yawing moment. The plate on the transverse bar is again used to set up moments which are balanced by the yawing moment of the model imposed by the ailerons or rudder. Rotation of the frame about the points O_1 O_2 now alters the incidence of the model, while permitting the measurement of the moments about the axis B fixed with respect to the model.

The two photographs, Fig. 25, show the general arrangement of the apparatus. In Fig. 26 the photograph on the left shows different attachments, and the photograph on the right the method of mounting the model on the attachment.

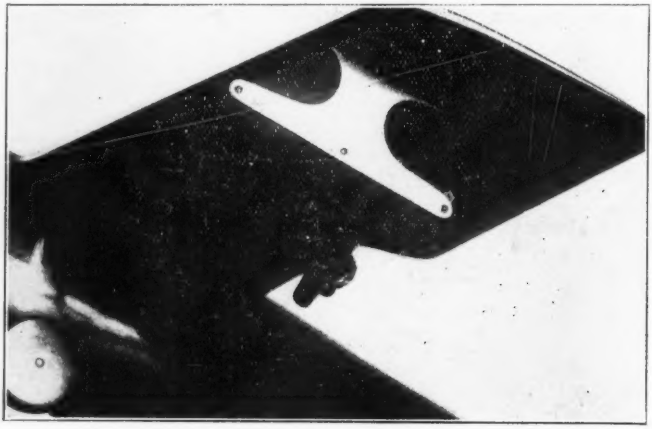


FIG. 23B.

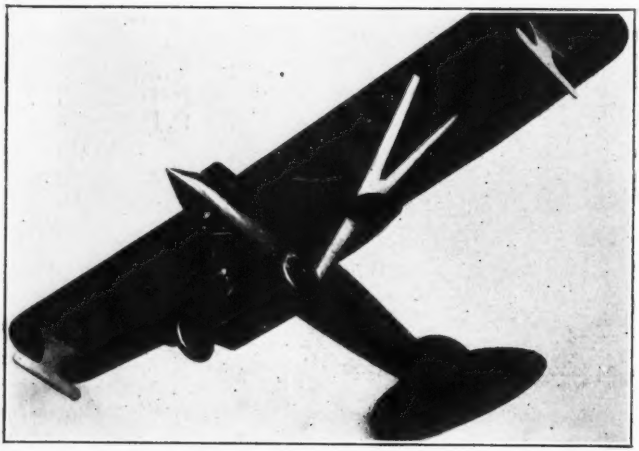


FIG. 23C.

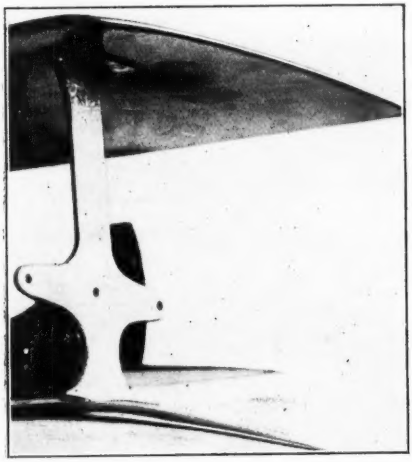


FIG. 23D.

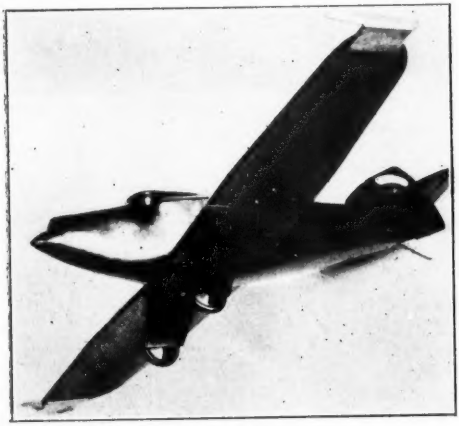


FIG. 23E.

Fig 1. Schema du montage de la maquette dans les essais en stabilité en route

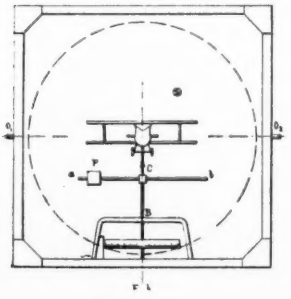


FIG. 24.

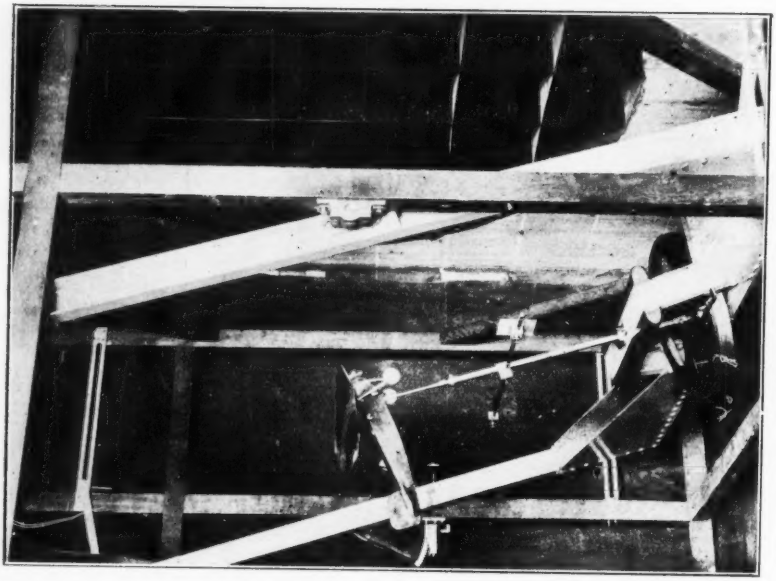


FIG. 25 (RIGHT).

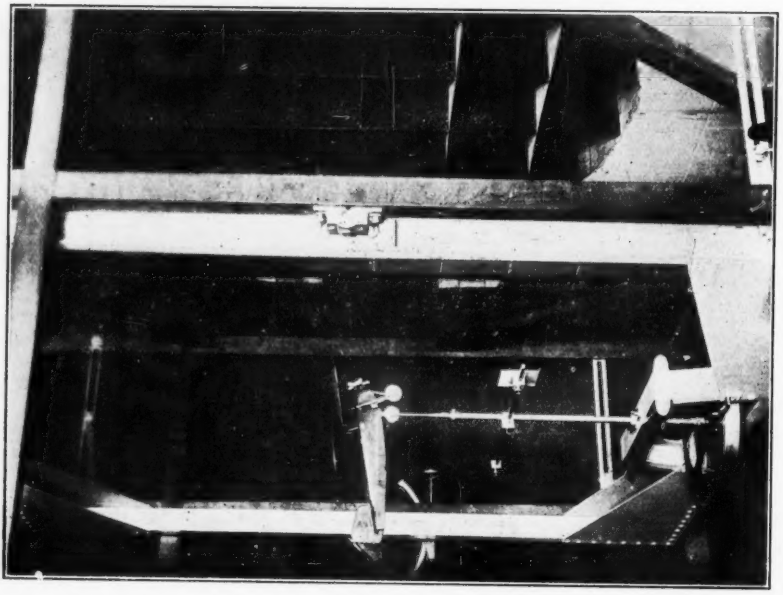


FIG. 25 (LEFT).

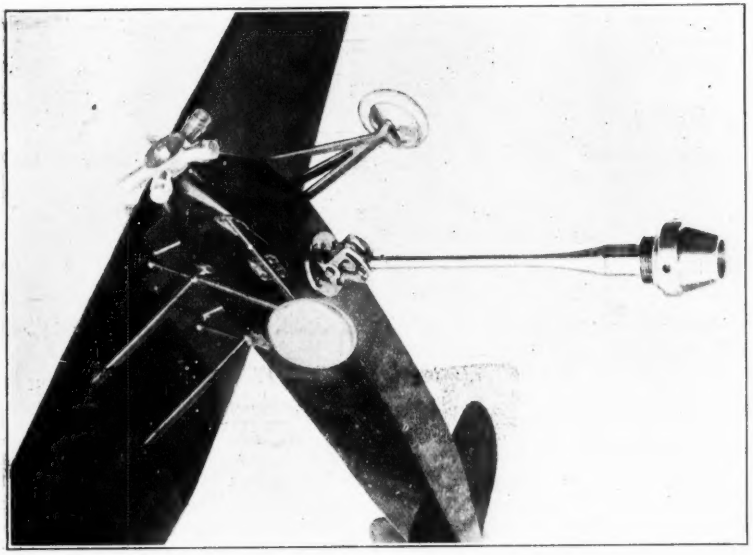


FIG. 26B.

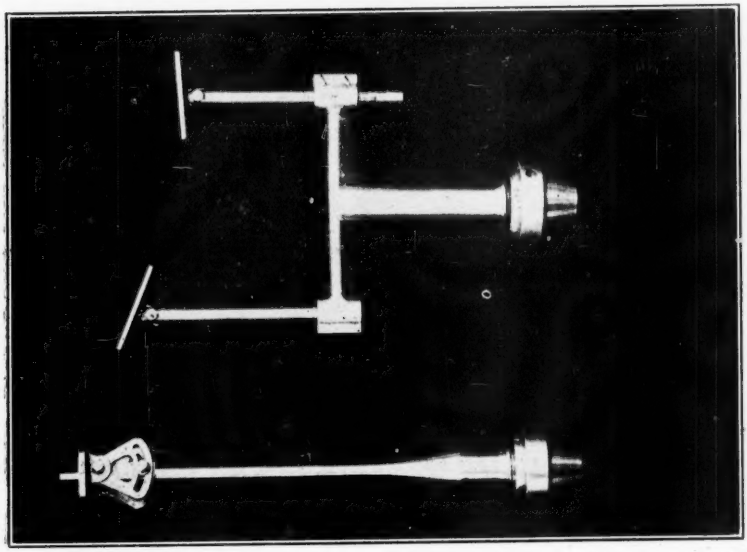


FIG. 26A.

Rolling Stability

Apparatus has now been designed for the investigation of rolling stability and rolling moments, but has not yet been completed.

Examples

Pitching Stability

A non-dimensional coefficient of pitching moment about the centre of mass is defined by the equation

$$C_{mg} = 2gM_g/aV^2S \cdot t$$

where a = density of air;
V = wind speed;
S = lifting surface;
t = chord.

The incidence is in general that of the longitudional axis to the wind; zero lift occurs at about -5° incidence for the models tested.

Positive moments are nose heavy; portions of the curves ascending to the right are consequently stable regions and portions of the curve descending to the right unstable. Horizontal portions indicate neutral equilibrium.

Fig. 27 illustrates the role of the tail unit. The curve for the model without any tail unit has two stable branches to the left of A and to the right of B, while the portion AB is an unstable region. The latter covers the whole range of practical flying incidence. The unstable region ends usually as at A, where a very marked nose heavy moment is indicated, which cannot be reduced for a given wing system except by advancing the axis of pivoting. The addition of a fixed tail surface reduces the zone of instability AB considerably, and when in addition the elevator is added the range AB becomes a zone of slight stable moment. From the model results it may be considered that the stabilising surfaces of the full sized aeroplane were well designed.

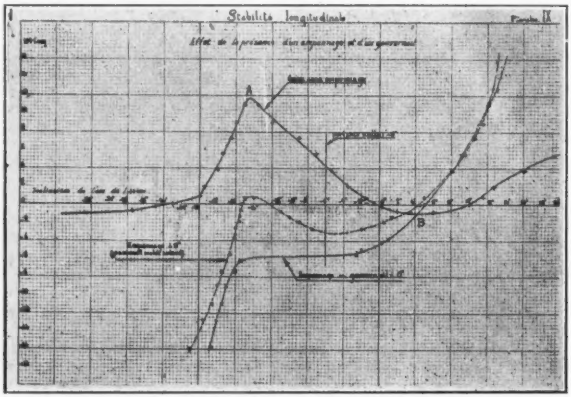


Fig. 27.

The curves in Fig. 28 show in a similar manner the effects of fixed tail surfaces, S_1, S_2, S_3 with 15, 18.5 and 21.5 per cent. respectively of the lifting surface. In this case the aeroplane was somewhat short with the centre of mass at about 37 per cent. of the wing chord from the leading edge, rather further aft than usual. Under these conditions only the larger surface S_3 is sufficient to eliminate the unstable zone.

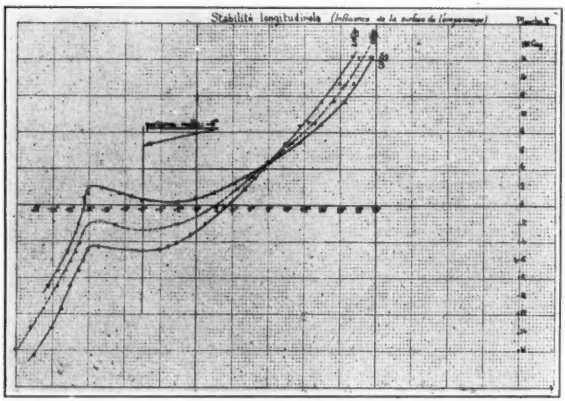


FIG. 28.

Fig. 29 gives moment curves for two different settings of the tail plane with respect to the line of flight. There is little change in the general form of the curve for the different settings, both cases showing a slightly unstable zone lying between two stable zones. The incidence of equilibrium on the other hand determined by the intersection of the curves with the horizontal axis, axis of zero moment, is seriously affected.

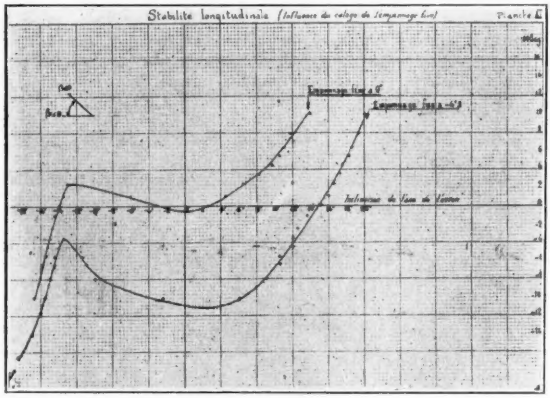


FIG. 29.

These results are in agreement with the usual conclusions of the elementary theory of stability.

Figs. 30, 31, and 32 show the modifications of the curves of moments for different settings of the elevator. Fig. 30 shows in every case a single range, stable throughout; Fig. 31 shows a zone of neutral stability extending over the usual angles of flight and separating two stable zones. Fig. 32 shows an unstable zone lying within the flight range of incidence and separating two stable zones.

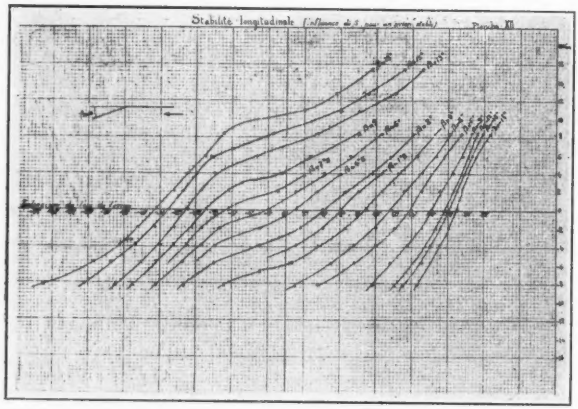


FIG. 30.

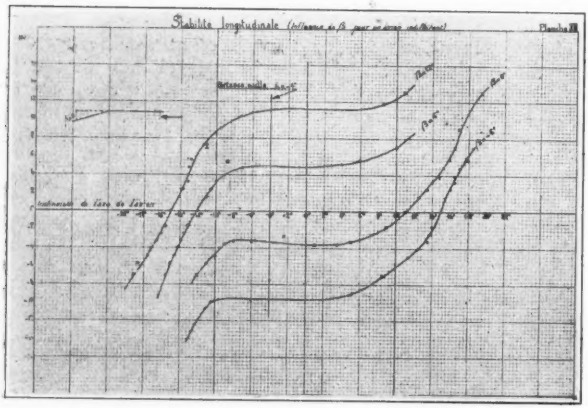


FIG. 31.

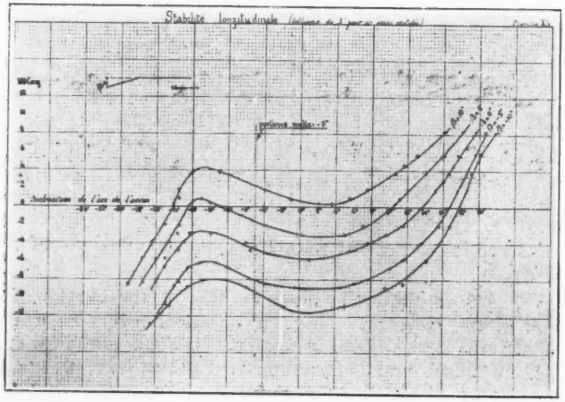


FIG. 32.

It is clear that the general shape of these curves as in Fig. 29 undergoes only slight changes for different settings of the elevator. As a first approximation it may be said that the moment curves are simply displaced vertically upwards, remaining parallel to themselves, as the elevator is depressed. In effect the elevator, for a given setting, imposes a moment which remains constant substantially through the ordinary range of flying incidence. Fig. 33 shows

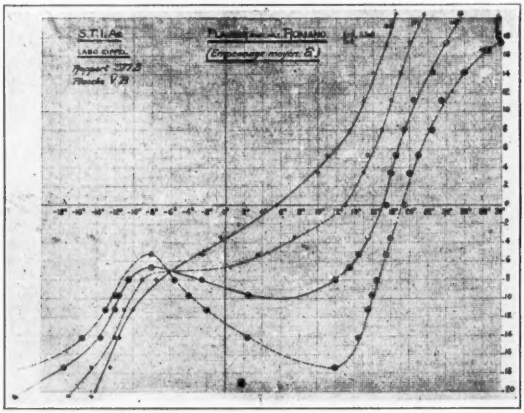


FIG. 33.

the effect on the curves of moment produced by shifting the centre of gravity successively to points 30, 35, 40 and 45 per cent. of the chord behind the leading edge.

In the first case the aeroplane is everywhere very stable; in the second case there is a neutral zone; and in the other two cases an unstable zone.

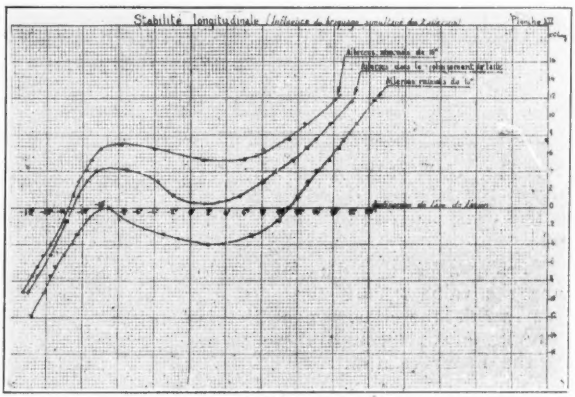


FIG. 34.

Fig. 34 shows the effect on the moment curves produced by angular displacements of the ailerons in a symmetrical manner. This is equivalent to modifying the profile of the wing, and gives some idea of the effect of the shape of the profile on the stability.

The principal effect is very similar to that of the elevator, and shifts the curve vertically upwards as the ailerons are depressed simultaneously.

Measurements were made with the ailerons displaced in opposite directions, plus 16° right aileron $-16°$ left aileron, and in this case the curve of moments remains sensibly as with both ailerons tangential to the wing. Fig. 35 shows the curve of moments with zero yaw and with 20° yaw. The effect on the pitching stability is seen to be slight.

From these tests it was concluded that the area of the tail plane and the position of the centre of gravity were the principal factors affecting longitudinal stability, and systematic tests were carried out with the object of obtaining a formula for the trim of a monoplane of normal type for neutral equilibrium.

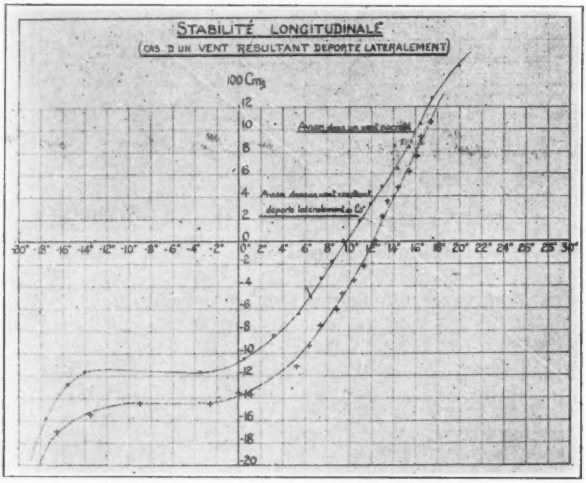


FIG. 35.

From the preceding tests it appears that aeroplanes tend to show the most feeble stability in the neighbourhood of nose-diving incidence. The object of the investigation was accordingly to obtain indifferent equilibrium in this neighbourhood.

Fig. 36 shows a model aeroplane and various tail surfaces employed. For each tail plane the value x/t = distance of c.g. from leading edge/chord was determined, at which there was neutral stability at nose-diving incidence. Drawing a smooth curve through these values Fig. 37 was obtained giving approximately the linear relation

$$x/t = 0.225 + 0.37\, S_e\, L/S\, .\, T$$

where S_e is the tail surface, S = lifting surface, t = chord, L = distance from $\frac{1}{4}$ chord behind the leading edge to the hinge of the elevator.

This formula suffices to fix approximately the trim of a projected aeroplane.

Further experiments are in hand to determine the modification of this formula required for parasol monoplanes and monoplanes with low-set wings.

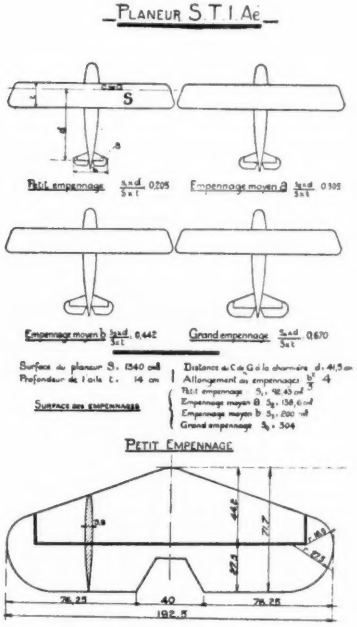

PLANEUR S.T.I.Ae
S
Petit empennage
Empennage moyen A
Empennage moyen b
Grand empennage
Surface du planeur S. 1340 cm²
Profondeur de l'aile t. 14 cm
Distance du C de G à la charnière d. 46,5 cm
Allongement des empennages
SURFACE DES EMPENNAGES
Petit empennage S. 92,45 cm²
Empennage moyen A S. 138,6 cm²
Empennage moyen b S. 200 cm²
Grand empennage S. 304
PETIT EMPENNAGE
76,25
40
76,25
192,5

FIG. 36.

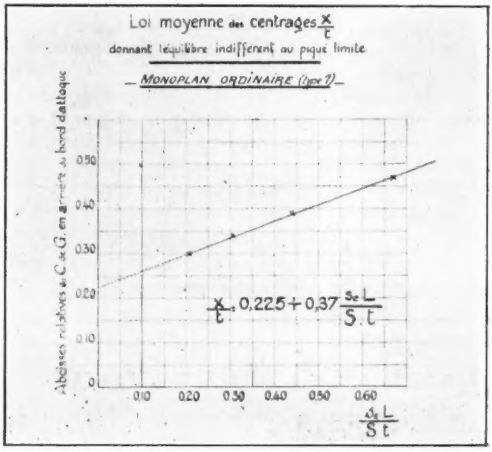

Loi moyenne des centrages X/t
donnant l'équilibre indifférent au pique limite
MONOPLAN ORDINAIRE (type T)
Abscisses relatives du C de G en arrière du bord d'attaque
0.50
0.40
0.30
0.20
0.10
0
0.10
0.20
0.30
0.40
0.50
0.60
X/t = 0,225 + 0,37 Sc L / S t
Sc L / S t

FIG. 37.

Directional Stability

Fig. 38 shows yawing moments on a model of a transport aeroplane under investigation. The abscissae are angles of yaw, θ, the ordinates are the non-dimensional coefficients of moment C'_{mg} (defined in the same way as C_{mg} for pitching stability) with respect to the vertical axis through the centre of gravity. Each of these curves corresponds to a given flying incidence ($i = -10°$, $-5°$, $0°$, $5°$, $10°$). The positive direction of the couple is taken so that when the aeroplane receives an angular displacement clockwise, a counter clockwise restoring moment is set up and *vice versa*. When the curve rises to the right a restoring moment increases with displacement, and a disturbing moment diminishes, passes through zero and finally becomes an increasing restoring moment.

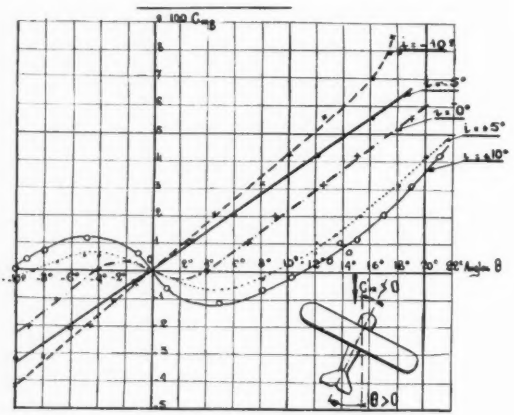


FIG. 38.

When the curve of moments falls to the right the opposite process takes place.

It follows that curve of moments rising to the right is necessary for stability. It is now seen from the figure that from $i = -10°$ to $i = -5°$ there is one position of equilibrium only, $C'_m = 0$, $\theta = 0°$; the curves of moment are rising to the right and their slope indicates a strong restoring moment for any directional disturbance within these limits of incidence. From incidence $i = 0°$ upwards there is a region of instability lying between two stable zones, and there are three positions of equilibrium at which $C'_m = 0$. From Fig. 38 it is seen that the position of equilibrium with zero yaw is unstable, but that the positions of equilibrium on either side of the origin are both stable.

It follows that the pilot must continually make small corrections with his rudder to maintain steady flight with zero yaw.

The stable positions correspond to considerable yaw displacements as is seen from the following table :—

ORIENTATION FOR DIRECTIONAL STABILITY.

Incidence.	Yaw.
0°	± 4°
5°	± 9°
10°	±11°

These undesirable phenomena were due to the fact that the vertical stabilising fin had insufficient depth and was masked by the body at large angles of incidence.

An aeroplane properly designed in this respect gave the curves of yaw moments shown in Fig. 39, which indicates satisfactory stability up to 10° incidence.

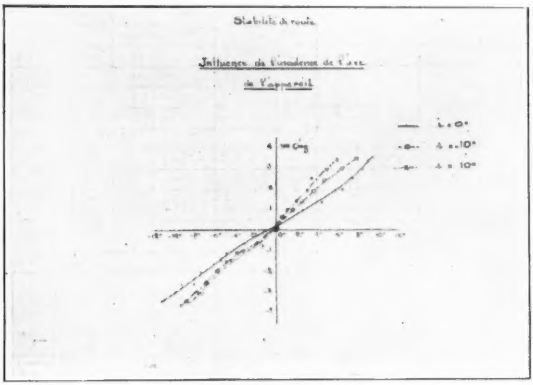


FIG. 39.

Fig. 40 shows the influence of rudder setting on the curve of yawing moments.

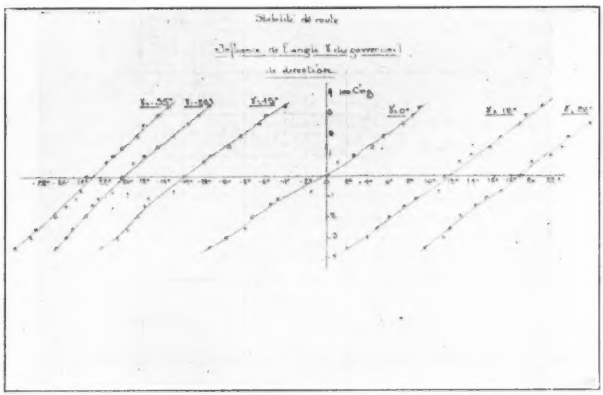


FIG. 40.

The curve is simply displaced parallel to itself without serious alteration of its slope, which shows that the rudder merely superposes a constant yawing moment.

Fig. 41 shows the effect on directional stability of conjugate motions of the two ailerons. This manœuvre likewise does not affect seriously the directional stability within a wide range.

These are the principal results obtained by the pivot mounting apparatus.

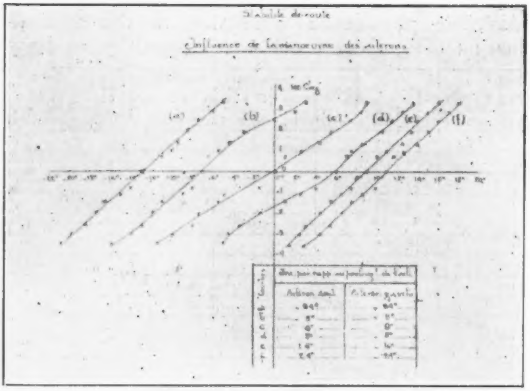


FIG. 41.

Leaving the field of technical investigations, the more scientific research work on the velocity field round a wing profile carried out by the present speaker will be described.

EXPERIMENTAL INVESTIGATION OF THE VELOCITY FIELD ROUND A WING PROFILE

The object of the research was the determination of the velocity V in magnitude and direction, and of the static pressure p at each point in the disturbed region in the median plane of a lifting wing, for different incidences in a stream of air of large cross section and of uniform velocity before reaching the wing.

Similar investigations have been carried out in England, particularly by Messrs. Bryant and Williams, but the method utilised by the speaker, enunciated in principle in 1912, allows of the determination of both pressure and velocity, while the method of Messrs. Bryant and Williams determines the velocity only.

In these researches application has been made of the properties of a simple Pitot tube, with its nozzle bent at right angles. When set facing the stream such a tube, as is well known, transmits a pressure

$$P + \lambda\delta V^2/2g$$

δ being the density of the air for the prevailing temperature and pressure, and λ being an empirical coefficient, very nearly unity and determined by previous calibration under known conditions.

The same tube turned through 180° transmits a pressure

$$P - \mu\delta V^2/2g$$

μ being another empirical coefficient which was found by calibration to be approximately 0.2.

From these two determinations P and V can be calculated.

The direction of the velocity vector is indicated by a light thread attached to the Pitot tube and enabling the latter to be set parallel to the streamline.

The thread is so light that it indicates turbulent motion. The final form of the apparatus is shown in Fig. 42. It consists of two Pitot tubes, close together and differing in orientation by 180°, mounted on a tube carried by a turntable, which in turn is mounted on a slide.

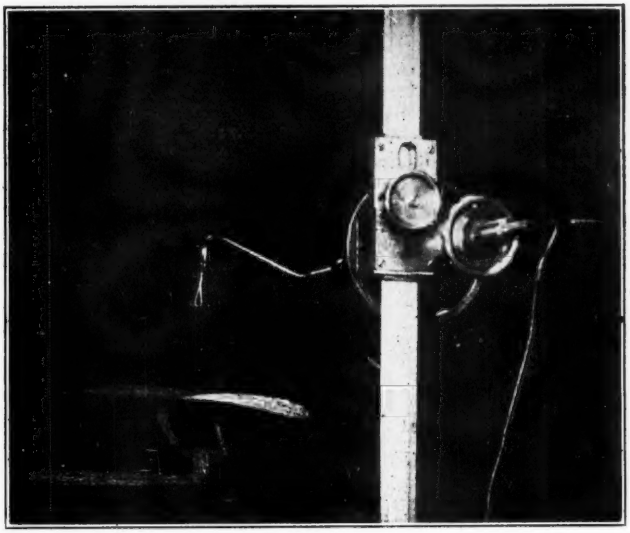
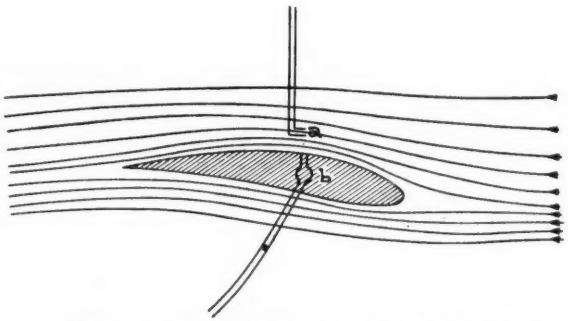


FIG. 42.

The apparatus may fail in regions of rapid gradients of velocity and pressure, but to reduce this defect to a minimum the Pitot tubes are constructed of hypodermic needles of 1.3 mm. exterior diameter.



Controle de l'Inter-action de la sonde et de l'aile en essai

FIG. 43.

The apparatus may further introduce disturbances into the velocity field by mutual interactions with the wing in exploring the region close to the surface. To avoid this the pressure on the wing surface has been measured by means of small orifices drilled in the wing and connected by internal ducts to a sensitive manometer. So long as the indications of the manometer do not vary it is assumed that the proximity of the Pitot head does not produce any serious interaction in the neighbourhood of the orifice connected with the manometer.

Experiment on a Model

A Joukowsky profile, G 430, was selected, of rectangular plan, 90 cm. by 18 cm., that is, aspect ratio 5.

This was exposed to the airstream 2 m. diameter of the Eiffel laboratory for 8 different values of chord incidence with respect to the undisturbed stream.

The chord incidence is denoted by i, and the incidence of the line of zero lift by β. C_z is the non-dimensional coefficient of lift and is independent of the units used, kilogram-metre-sec.

	i	$-8.3°$	$-6.1°$	$-4.0°$	$-1.9°$	$0.2°$	$4.5°$	$9.0°$	$16.5°$
β	... ...	$0°$	$2.2°$	$4.3°$	$6.4°$	$8.5°$	$12.8°$	$17.3°$	$24.8°$
C_z	Complete wing ...	$0°$	$0.15°$	$0.30°$	$0.45°$	$0.60°$	$0.90°$	$1.20°$	$1.65°$
	Median section ...	$0°$	$0.15°$	$0.32°$	$0.49°$	$0.65°$	$0.98°$	$1.26°$	$1.32°$

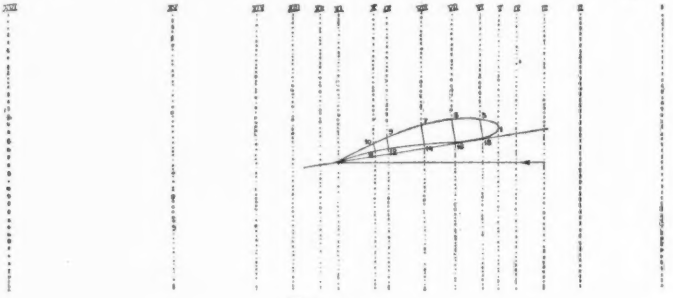


FIG. 44.

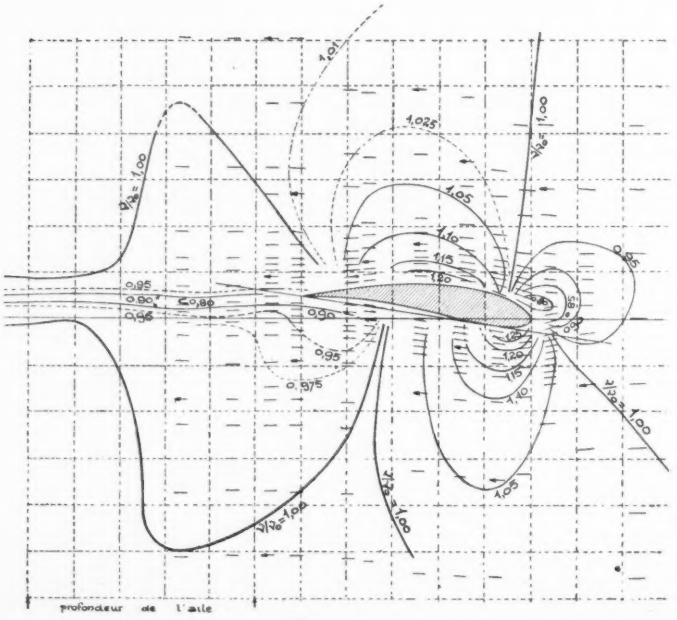


FIG. 45.

For each value of the incidence the velocity and pressure fields were explored along 18 vertical sections as shown in Fig. 44, beginning 18 centimetres, 1 chord length before the leading edge and ending at 36 cms., 2 chord lengths behind the trailing edge. The depth explored was usefully extended to about 2 chord lengths above and below the wing.

Principal Results

(*a*) Diagrams showing low curves of equal velocity (isovels).

The representation of the velocity field may be based upon the ratio v/V_0, the ratio of the velocity at a point to the undisturbed velocity, and by the inclination of the streamlines, α ($\alpha > 0$ ascending current, $\alpha < 0$ descending current).

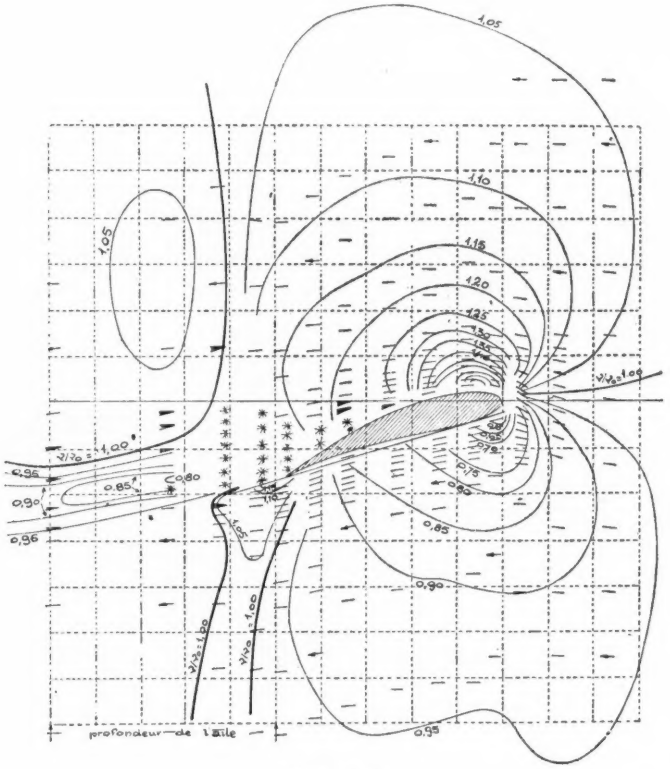


FIG. 46.

The pressure distribution may be specified by the ratio $\Delta p/H$, where Δp is the excess of local pressure over the pressure in the undisturbed stream and H is the pressure corresponding to V_0 ($\Delta p > 0$ denotes compression, $\Delta p < 0$ denotes rarefaction). The ratios v/V_0 and $\Delta p/H$ are numbers without dimensions, and in a consistent system of units are independent of the magnitude of the unit. Figs. 45, 46 and 47 are diagrams of isovels for values of the incidence, $-8.3°$, $16.5°$ and $-4°$, and give for each point of the field, by inter-

polation, the numerical value of the relative speed at the point. The horizontal lines are parallel to the undisturbed direction of flow and the wing profile is shown at the appropriate incidence. The mesh of the square ruling has a side equal to one-fifth of the chord.

The short straight line segments are parallel to the streamlines at the points of observation.

From these diagrams the influence of the profile at a distance may be studied, particularly the influence of the leading edge of the infliction of the pressure

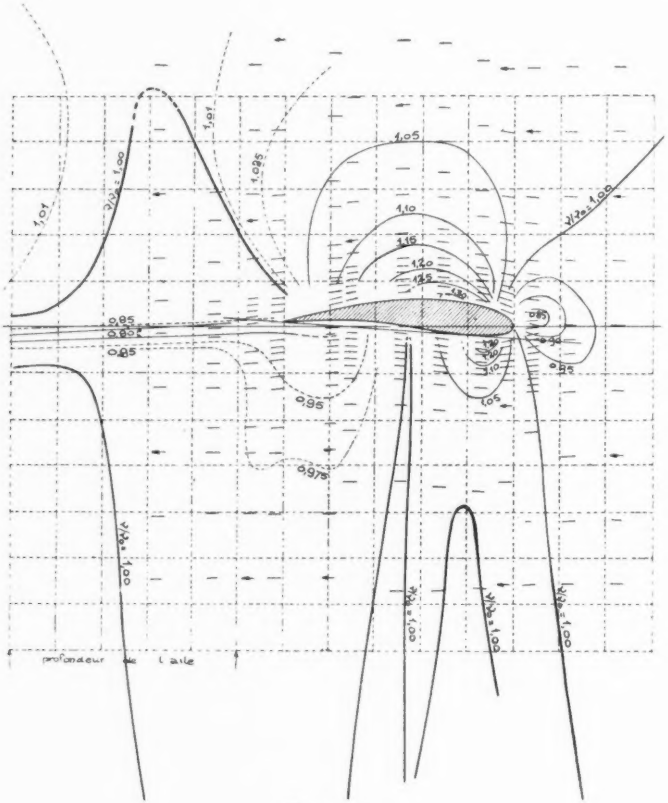


FIG. 47.

surface, etc., on the velocity locally. It is also seen of how little importance is the disturbance behind the wing with the exception of the wake to which reference will be made later. The numbers corresponding to the isovels differ little from unity and since the disturbances are feeble the contours are necessarily somewhat uncertain. A suitable position for air speed indicators appears to be the point above the trailing edge where the disturbance of the velocity is very small.

Other practical conclusions may be drawn.

It is customary to place on wings small windmills driving electrical generators.

It is seen that the velocity to which they are exposed may be from 20 to 30 per cent. and even more above the undisturbed speed for which they are often designed.

(*b*) In front of the leading edge a region is noted of some extent where the velocity is considerably less than that of the undisturbed stream. This fact may explain certain discrepancies noted in the working of airscrews placed before very thick wings. This consideration might render it advisable to adopt wings with a profile more or less shallow at the leading edge. As a further example of interpreting these diagrams it will be noticed that in Fig. 45, which corresponds to zero lift, there are two regions of high velocity and therefore of low pressure, one on the upper surface and one on the lower surface, but staggered with relation to each other. This explains the presence of a large value of the pitching moment, C_m corresponding to zero lift, acting so as to produce nose heaviness.

Distribution of Pressure in the Neighbourhood of a Profile

The isovels of Figs. 45, 46, 47, may be taken as isobars excepting in the boundary layer and the wake on the assumption that outside these regions the air acts as a perfect fluid, to which we may apply Bernoulli's theorem which in our notation is written

$$\Delta p / H = 1 - (v / V_0)^2$$

from which it is seen that if v/V_0 is greater than unity there is rarefaction.

Considering now the boundary layer it is difficult to define it precisely, but its influence was noticed when the small pitot head approached within a distance varying from 5—25 mms., and the surface Σ was drawn enveloping the profile within which attempts at measurement were vitiated by these effects of interaction.

Fig. 48 shows the boundary surface thus determined for three different values of the incidence. The normals to the surface and the ends of the vertical sections, along which the explorations of the velocity field were made, are drawn in. The length of the intercepts between the surface of the profile and the surface of the boundary layer determines the ratio $\Delta p/H$ over the surface Σ. A comparison of this pressure with the pressure transmitted directly from the orifices to the manometer gives an indication of the variation of pressure in the boundary layer. The numerical values of pressure ratios $\Delta p/H$ are entered in Fig. 48 from which it appears that the pressure gradient dp/dn along the normals to the profile are extremely small in the boundary layer although the velocity of the fluid is subject to heavy variations on account of the viscosity, in other words, there is no sensible variation of pressure along the normal to the profile in the boundary layer. This rule does not apply so rigorously near the leading edge on account of the high curvature of the streamlines.

A practical conclusion from these results is that where measures of pressure cannot be carried out by orifices in the surface connected by internal ducts to a manometer it is sufficient to measure the pressure in the fluid in the neighbourhood of the profile.

(*c*) *Exploration of the wake.*

The velocity field behind the profile is characterised by a rapid diminution of the disturbance of the velocity field and of the pressure distribution which still follow Bernoulli's relation, except in a comparatively narrow belt called the wake. This region begins at the trailing edge, above and below and extends indefinitely down stream. But the disturbance of the general direction of the flow extends far above and below the wake properly so-called.

In the wake itself large variations of velocity are observed, but the gradient of the static pressure along the normal to the streamline is zero up to the boundary of the wake at which the pressure is determined by Bernoulli's relation.

Fig. 49 shows the velocity ratio v/V_0 in the wake at different distances

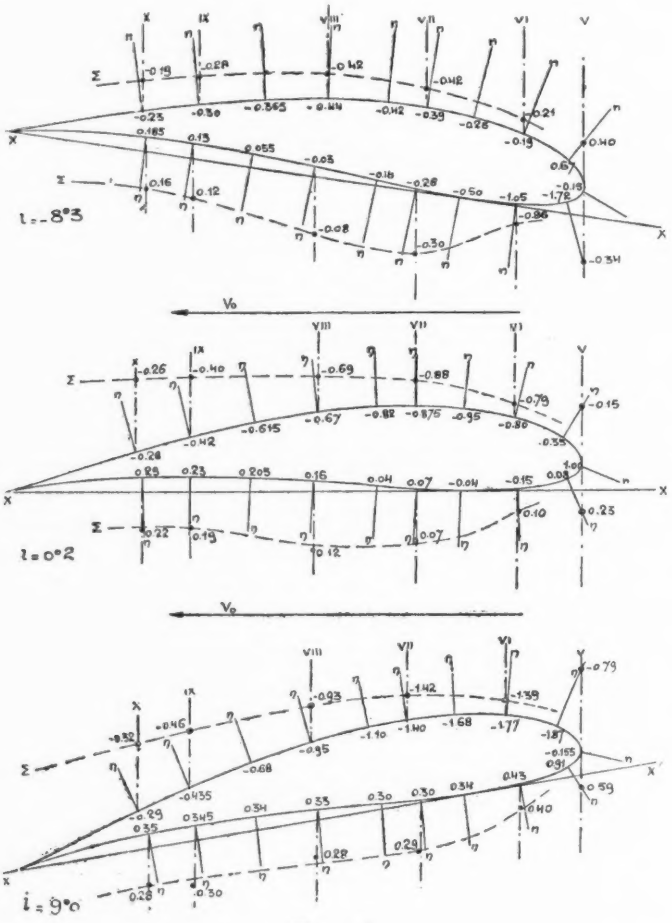


FIG. 48.

from the trailing edge for incidence $i=4.5°$ (or $\beta=12.8°$). It is seen that the depth of the wake increases slowly down stream, and that the velocity distribution becomes more uniform while the point of minimum wake velocity descends steadily, with the general downwards deflection of the whole stream.

The wake has a form which changes little with wing incidence so long as the incidence giving C_z max. is not exceeded.

The upper and lower limits are substantially rectilinear, and appear to originate from points at most 5 mm. above and below the trailing edge.

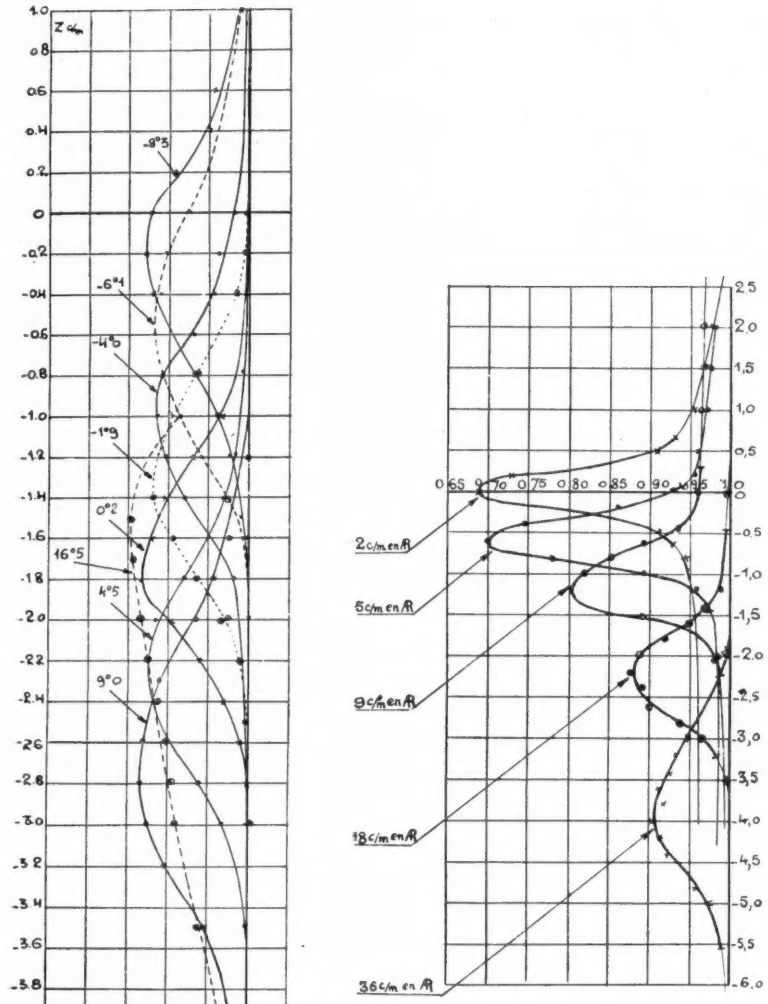

Z/c
-9°3
-6°1
-4°6
-1°9
0°2
16°5
4°5
9°0
0,65 0,70 0,75 0,80 0,85 0,90 0,95 1,0
2c/m en A
5c/m en A
9c/m en A
18c/m en A
36c/m en A

FIG. 49.

The hatched area in Fig. 50 shows the cross section of the wake as just described. Its external form does not change sensibly, but it becomes more inclined with increasing incidence according to a relation which will be defined presently.

The locus of minimum wake velocity in the successive sections explored is sensibly a straight line inclined to the undisturbed stream at an angle γ, which is a function of the incidence β (measured from the no lift position) expressed by the empirical formula

$$\gamma = 1^\circ + 0.42\,\beta.$$

Excepting for small values of β the relations may be written in the simple approximate form

$$\gamma = \beta/2$$

The latter is shown graphically in Fig. 50.

The straight line $\gamma = \beta/2$ divides the wake into two unequal parts, and lies nearer the upper boundary, and farther from the lower boundary.

It is important to investigate the influence of aspect ratio on the relation between γ and β.

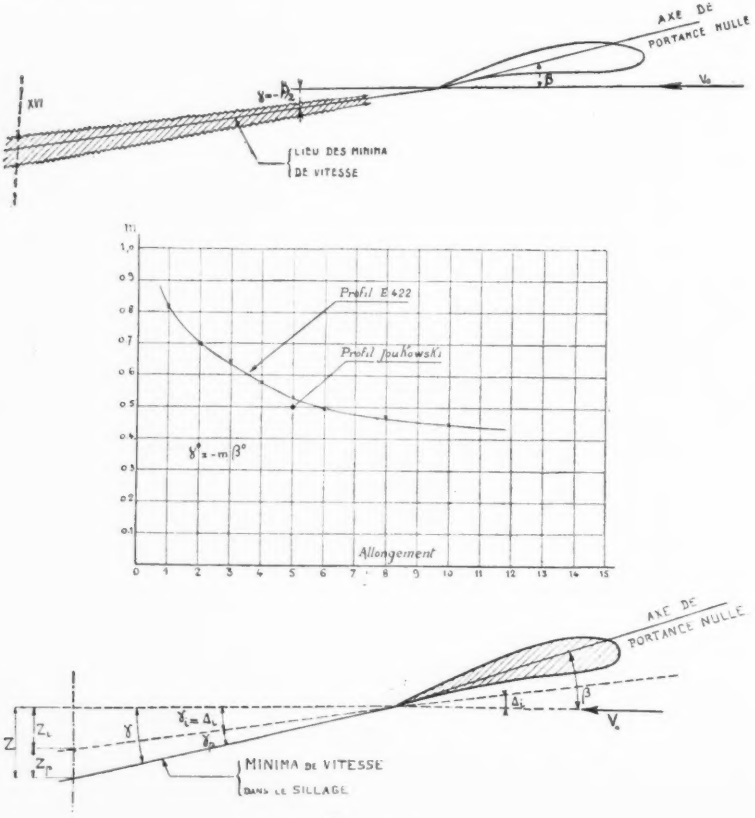


FIG. 50.

For this purpose a series of experiments was carried out with a profile approximately plano-convex. Starting with a rectangular wing of span 175 cms. and chord 17.5 cms., aspect ratio 10, the span was diminished successively to give aspect ratios 8, 6, 5, 4, 3, 2, 1, by cutting portions from the tips.

It was found that the relation could be expressed in the form

$$\gamma = m\beta$$

where m is a function of the aspect ratio shown graphically in Fig. 50. The value of m for the Joukowsky profile of aspect ratio 5 is marked on the figure and lies near the curve, so that the profile has relatively small influence on the value of m, in comparison with the considerable influence of the aspect ratio,

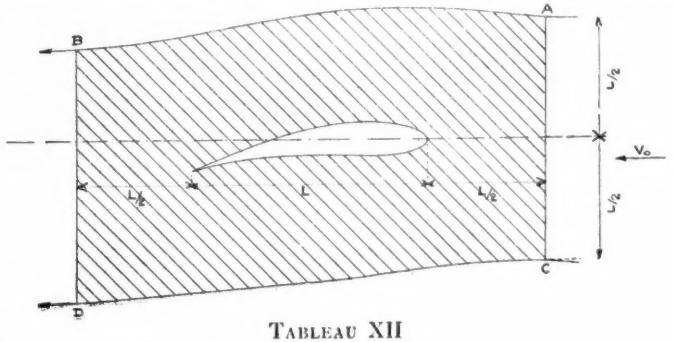


TABLEAU XII

INCIDENCE i	ELEMENTS DU CALCUL DE $C_z \times 10^2$					
	PARTS DÛES AUX QUANTITES DE MOUVEMENT à travers		PARTS DÛES AUX PRESSIONS STATIQUES suivant		C_z RESULTANT DE LA SOMME DES EFFETS DES QUANTITES DE MOUVEMENT ET DES PRESSIONS STATIQUES	C_z CALCULES D'APRES LE RELEVÉ DES PRESSIONS LE LONG DU PROFIL
	AC	BD	AB	CD		
-8°3	1.4	0	4.3	-6.0	-0.3	-0.1
-6°1	2.8	0.3	10.4	-1.9	11.6	14.9
-4°0	6.1	1.4	16.6	3.9	28.0	32.5
-1°9	7.9	6.0	23.3	8.3	45.7	49.0
0°8	9.8	9.9	28.6	10.7	59.0	65.0
4°5	13.6	15.6	37.7	23.0	89.9	97.7
9°0	17.6	24.5	50.6	30.6	123.3	125.8
16°5	20.4	25.2	56.3	32.6	134.5	132.3

FIG. 51.

which deflects the wake downwards more and more as the aspect ratio becomes smaller and smaller, for a given value of β.

Calculating the induced deflection γ_i by Prandtl's methods and subtracting from γ there remains finally,

$$\gamma_p = 0.30\,\beta$$

independently of the aspect ratio.

This formula may also be used for the calculation of γ should such a curve as that of Fig. 50 not be available.

Deflection of the Stream Behind the Wing

The general deflection, α, of the stream behind the wing is given to a first approximation by

$$\alpha = \gamma = m\beta$$

and this formula may be used for the mean deflection of the stream meeting the tail unit, neglecting the disturbances which are in fact produced by the body.

Some irregularities must be noted in that part of the wake where the two branches of the stream, coming from above and below the profile, meet.

Finally, it is to be remarked that we have not observed the undulations of the current, first noted by M. Besnard, then by von Karman, and recently brought out by the experiments of MM. Toussain et Carafoli.

Hydrodynamical Theory

The results of this experimental exploration of the velocity field and pressure distribution may be compared with the results of hydrodynamical theory, in particular (*a*) the principle of the conservation of momentum and (*b*) the circulation theory of lift, and with this comparison we shall bring the paper to an end.

(*a*) Applying the principle of momentum in the disturbed stream to obtain the components of lift and drag the following interesting results are obtained.

The profile is enclosed in a control surface, Fig. 51, bounded in front and behind by planes normal to the stream at distance $\frac{1}{2}$ chord from the leading and trailing edges, and above and below by streamlines passing through points on the forward surface at $\frac{1}{2}$ chord above and below the leading edge. The change of momentum in this region accounts only for 1/3 of the lift, the remaining two-thirds being accounted for by differences of pressure on the lower and upper surfaces.

With respect to the drag of the profile the change of momentum in a normal section, one chord length behind the trailing edge, indicates a dissipation of energy in heat accounting for less than half the drag, and a dissipation at any finite distance less than sufficient to account for the drag.

(*b*) With regard to the circulation component of the velocity required to produce the observed lift, corrected for Prandtl's induced incidence, the calculated and observed values agree within 5 per cent., excepting in the wake, where the discrepancies are greater. The circulation theory of lift thus receives confirmation from the results of experimental aerodynamics.

Discussion

The President: The paper gave the results of work carried out at the Eiffel Laboratory during the past year, and, in addition, a wealth of illustrations and particulars of the methods now in use, many of them due to the ingenuity of the author. It might be remembered that some time ago a Past Chairman of the Society—Colonel O'Gorman—in referring to the work of M. Eiffel and that famous book published in 1911, said not only was it a work full of the most valuable information but it was an example of clear and systematic thinking that

might be taken as a lesson by all the world. There could be no doubt that the author was following in the footsteps of his great teacher, Eiffel.

Mr. PIERSON: Would the author say what is the approximate time taken for taking one set of pitch moment tests? Incidentally, he was very interested to see that the method described was quicker than his own. With regard to longitudinal stability with the propeller running, had the author done any experiments in his wind tunnel on this? The great difficulty in longitudinal stability was that with the engine on in the case of high speed scouts it was very difficult to get a machine of the required stability.

Captain GOODMAN CROUCH (who translated the remarks made during the discussion and replied on behalf of M. Lepresle): The experiments referred to took $\frac{1}{4}$-hour per curve to get all the observations. The author had not had an opportunity of doing any experiments on longitudinal stability with the engine on, but hoped to do so in the near future in the bigger tunnel of the Government Technical Service.

Mr. IRVING: The greatest tribute that could be paid to Eiffel was the fact that his original methods of experiment are still found to hold good and that in essentials they were unaltered at the present day. One always had a tendency to get rather too immersed in one's own work, and for that reason he felt it was particularly good to have our attention drawn to work which had developed on entirely different lines. He was thinking more particularly of the type of tunnel. The tunnels used in France were of the open jet type, whereas he believed all the tunnels in this country were of the closed type. It was, therefore, interesting to see to what difference in technique the difference in type of tunnel leads to. One interesting example was the longitudinal and lateral stability measurements by means of vanes. That, of course, was work which could not be conveniently carried out in the closed type of tunnel, whereas they had been told that it is possible to run through a set of experiments in the open type in the remarkably short time of $\frac{1}{4}$-hour. So far as it was possible to make a general comparison of the methods of technique in the two countries he thought it could be said that the chief difference in France in the methods adopted as compared with those adopted in this country is that, whereas in France they had kept to the rigid method of support, in this country one had, so far as possible, come round to the wires method of support. The reason was that here one was very keen to lessen interference as much as possible. In the early days there were some rather nasty shocks in the way of interference. Certain methods of support and certain supports which looked very satisfactory with regard to comparison gave the most erroneous results. It was not clear from the paper whether in France any method of damping in the apparatus—oil damping or otherwise—was used. It was often stated that a certain amount of damping was necessary, and usually it took the form of vanes moving in a dash pot of fairly thick oil, usually ordinary engine oil. That simple device was usually sufficient when working below stall, but in recent years when working above stall there had been found an increasing need for damping, and the most desirable arrangement seemed to be an adjustable one. What was required was an arrangement with a very wide range of damping and easily adjustable from nothing, or something very small, to something very heavy. The need for such an apparatus was particularly felt during some recent experiments with rotating models, in which most of the work had been done above stall. A report was on the point of being issued which described a very neat arrangement, in which a dash pot was used which did not fling any oil about. It had a rubber diaphragm for keeping the oil in. As there was the risk that ordinary oil would perish the rubber, a change had been made to glycerine. That device had a very simple adjustment over a wide range.

Captain GOODMAN CROUCH: The author wished to get into communication with Mr. Irving and hear his views as to the necessity for damping. Hitherto the author had found no necessity for it, but would be interested to compare notes

with Mr. Irving. As to the rigid method of support, the author felt that the interference is negligible. That was a quite definite opinion after carrying out a large number of experiments.

Dr. RICHARDSON: He had not had the pleasure of seeing the Eiffel Laboratory, but he had had the opportunity of seeing the laboratory at St. Cyr, directed by M. Toussaint, which, he believed, was modelled on Autueil. He had been interested in what Mr. Irving had said, because the thing that struck him at St. Cyr was that everything was supported on wires and there were no struts visible on the occasion of his visit. Apart from that, he was particularly interested in the last part of the paper describing the velocity distribution, as Dr. Piercy and himself had been making similar experiments but using hot wire instruments. In fact, the measurements they had obtained were almost entirely outside the range of the author's, because they were all within the zone where the Pitot tube failed. The author stated that in Fig. 45, which corresponds to zero lift, there are two regions of high velocity and therefore of low pressure, one on the upper surface and one on the lower surface, but staggered with relation to each other, and it was suggested that this produces nose heaviness. In the case of their own aerofoil, said Dr. Richardson, which had a flat under-surface and a sharply pointed nose, they got these two regions exactly opposite to each other, and he would ask the author whether he thought the result he had indicated was characteristic of his own particular aerofoil or whether he had found the same thing with other aerofoils.

Captain GOODMAN CROUCH: M. Lapresle had come to the conclusion from the experiments that had been made at the Eiffel Laboratory at Autueil and at Issy les Moulineaux that no correction is necessary for the difference in support by wires and the rigid support. The same results had been obtained in both cases. The conclusion, however, was limited to fixing by the rigid method from the under-surface and not on top. With regard to the other point raised, M. Lapresle was of the opinion that the result mentioned was characteristic of the particular aerofoil.

Dr. DOUGLAS: The open type of tunnel developed by Eiffel was growing more and more in favour for various reasons, and one had to thank one's French colleagues for the work they had done in developing the more economical tunnel, particularly with regard to expansion cones. When he was shown the tunnel at Issy les Moulineaux, Sebatier had told him that with 1,000 h.p. a 3-metre jet at the rate of 84 metres per second was obtained. He believed that was about double the efficiency of any wind tunnel in this country. He had often envied the simplicity of the method of measuring forces and moments by the balancing vane method. It must be delightful not to have to worry about the exact wind speed. He had tried to work that into some schemes, but had always been rather worried about the interference between the plate and the model. In order to use that scheme one must have a bigger tunnel, it seemed to him, but he would like the author's views on that point.

Captain GOODMAN CROUCH: M. Lapresle could confirm the figures attributed to Sebatier as regards the tunnel at Issy les Moulineaux. As to the second point, interference had to be catered for, but whether it was necessary to have a bigger tunnel the author was rather doubtful. He was inclined to think that a bigger tunnel is not necessary.

Mr. SCOTT HALL: He was interested in the paper because he had seen both the tunnel at the Eiffel Laboratory and also the tunnel at Issy les Moulineaux. He wished to ask some questions about the latter because it was not mentioned in the paper. When he paid his visit the author was just in the process of finishing the construction of the tunnel, and he was given to understand that all the forces measured on the models were carried out on an oil system—a compressed oil system. All the pressures were transmitted through an oil stream

to a distant point, where they were measured photographically. Had that system been developed and with what results, because it seemed a very unusual method? He also believed that the method of varying the speed was by varying the pitch of the propeller. What advantage had that over the ordinary method of varying the speed?

Captain GOODMAN CROUCH: M. Lapresle would very much like Mr. Scott Hall to communicate with him, when he would try and explain some of the points raised. With regard to the suggestion that the change of speed is obtained by varying the incidence of the propeller blades, the author felt sure that that was not done. It was simply a difference of rotational speed.

Major LOW (who, on the invitation of the President, proposed a cordial vote of thanks to M. Lapresle): Since the earliest days of aeronautics people in this country had drawn a great deal on France. Many had gone there to see the earliest aviation meetings and to learn to fly. Others had studied their methods of testing and measurement, and in no case could one say that there had not been a mutual profit made by exchange of views and exchange of methods. It was, in these circumstances, particularly appropriate that M. Lapresle—the man who had developed the latest ideas on the subject in France—should come here and describe them. The points of similarity with British work were interesting, and the points of difference were naturally even more interesting. There was no question of aero-dynamical research being the exclusive property of any one country. In this country one was proud of the very large share one had taken in advancing it, and one recognised that France was equally proud of the part that had been played by her scientists and engineers. He could not even exclude his old enemies, the Germans, nor his ally, America, where huge expenditure of money was leading the world in research, and to that large sum of money must be added no inconsiderable amount of brains. In all these circumstances it was with the greatest possible pleasure that he moved a vote of thanks to the representative of one of our Allies, which had carried out an enormous amount of practical flying and aero-dynamical research work.

Captain GOODMAN CROUCH: M. Lapresle thanked Major Low for his extremely kind remarks, but wished to make it clear that, although the paper as put forward might claim to be a French paper, all the original work leading up to the possibility of it being written had been English. He wished to stress that in all sincerity, particularly with reference to the work of Stanton. The author also wished to record, on behalf of his nation, his appreciation of the wonderful work done by English physicists for some time past, which had rendered advances in research work possible.

ABSTRACTS AND NOTICES FROM THE SCIENTIFIC AND TECHNICAL PRESS

No. 9, AUGUST, 1929

Issued by the Directorates of Scientific Research and Technical Development (Prepared by R.T.P.)

AIRCRAFT ENGINES, FUELS AND LUBRICANTS

1 Fuels, Dopes and Detonation

Theory of Cracking Petroleum. (H. A. Wilson, F.R.S., Proc. Roy. Soc., A., Vol. 124, No. 793, 2/5/29, pp. 16-45.) (8.512/10425 U.S.A.)

Following two previous papers (Vol. A., 116, p. 501, Vol. A., 120, p. 247). Algebraic formulæ are developed for the percentage distillate, based on molecular theory. Numerical tables are given of the percentage of liquid, petrol, gas and unsaturated compounds under pressures ranging from 7.5 atmospheres to 60 atmospheres, and temperatures from 750°F. to 1400°F.

The variation of the percentages with temperature is also exhibited graphically, showing a maximum of 60 per cent. gasolene at 120°.

It is pointed out that a single distillation does not determine the maximum yield, as some of the heavier distillates may be subjected to cracking in turn.

Gum in Gasoline. (Automotive Industries, 23/3/29, p. 487.) (8.512/10426 U.S.A.)

Fuels made by the liquid phase cracking process do not cause gum trouble in the petrol engine. If it is desired to make better anti-knock fuels, vapour phase cracking will probably be employed, and unless special precautions are taken these fuels may give trouble from valves sticking.

Knock Ratings of Pure Hydrocarbons. (A. W. Nash and D. A. Howes, Nature, 1929, 123, 526-527.) (8.514/10427 England.)

Accurate knock rating requires careful standardisation of methods. An acid refined unsaturated spirit has a lower anti-knock value than the original, since the ollefines only polymerise incompletely. Both for the ollefines and also possibly for the aromatics ease of oxidation appears to be connected with anti-knock value.

Knock Ratings of Pure Hydrocarbons. (S. F. Birch and R. Stansfield, Nature, 1929, 123, 490-491.) (8.514/10428 England.)

Polymerisation generally reduces the anti-knock value of the fuel. The behaviour of cyclo-hexane depends on the history of the sample. Hydro-carbons which possess conjugated double links have high anti-knock qualities. An increase in the length of a chain generally reduces the anti-knock properties. The reverse is the case for side chains attached to a benzene ring.

The Speed of an Explosive Wave. (P. Laffitte and P. Dumanois, Ann. Office Nat. Comb. Liquides 3, 121-2, 1928.) (8.514/10429 France.)

Experiments show that the speed of propagation of a detonating wave in mixtures of hydrogen and oxygen or methane and oxygen is not affected by the addition of .1 per cent. of tetraethyl lead.

X-Ray Quantitative Analysis of Tetraethyl Lead in Gasoline. (R. H. Aborn and R. H. Brown, Ind. Eng. Chem. Analy., Ed. 1, 26/7, 1929.) (8.514/10430 U.S.A.)

By comparing the sample with the X-ray photograph of standard solutions it is claimed that the lead tetraethyl content can be estimated to .1 per cent.

Effect of Anti-Knock Materials on the Speed of Initial Uniform Movement of the Flame in Hydrocarbon Air Mixtures. (Yuzaburo Nagai, Tokyo Imp. Univ. Proc. Imp Acad. 4, 525-8, 1928. Chemical Abstracts, 20/3/29, Vol. 23, No. 6, p. 1500.) (8.514/10431 Japan.)

The effect of $SeEt_2$, $SnMe_4$ and $PbMe_4$ on the speed of initial uniform movement of the flame in a mixture of air and hydrocarbon vapour has been studied. The hydrocarbon consisted of a mixture of about 43 per cent. dimethylcyclopentane and 57 per cent. isoheptane. The speeds of the initial uniform movement of the flame are distinctly lowered by the addition of the anti-knock materials, the speed concentration (of hydrocarbon) curve being lowered more and more with the increase in concentration of the anti-knock materials. When the concentration of $SnMe_4$ or $PbMe_4$ reaches 1 per cent., the curve is not lowered by further addition of these compounds, the concentration of $SeEt_2$ to produce the same result is about 2 per cent.

Standardisation of Conditions for Measuring the Detonation Characteristics of Motor Fuels. (R. Stansfield and F. B. Thole, Industrial and Engineering Chemistry, Analytical Edition, Vol. 1, No. 2, 15/4/29.) (8.514/10432 U.S.A.)

Three designs of engine are described with entirely different combustion chamber shapes and valve arrangements. Tests show that substantially equal results for anti-knock can be obtained from any of the engines if comparisons are made in terms of equivalent blends of standard spirits and provided that test conditions are suitably controlled.

The effect of each controllable variable is examined, the most important being the air fuel ratio and, in the case of tests with the bouncing-pin indicator, the compression ratio at which comparisons are made.

The air fuel ratio must be adjusted to give maximum pinking and, for bouncing-pin tests, the sample must be used undoped and the compression ratio adjusted to give the necessary evolution of gas in the voltmeter.

Experimental errors of different methods of test have been determined and vary from ± 2 to ± 0.25 per cent. of benzene in heptane, the bouncing-pin method giving the closest agreement between repeat tests.

N-heptane and pure benzene are suggested as suitable for standard reference blends, but there is need for a cheaper and more easily obtainable low-value spirit than heptane.

Combustion Control by Cylinder Head Design. (Robert N. Janeway, S.A.E. Journal, May, 1929, page 498.) (8.514/10433 U.S.A.)

Since detonation depends primarily upon the temperature attained by the residual unburned gas, it can be controlled by combustion chamber design which intensifies the heat transfer from the unburned gas to the walls.

The shock tendency, which originates in the pressure time characteristic of combustion, can be controlled only by deliberate incorporation of the desirable anti-shock characteristic in the chamber design by a method of calculation which is explained in detail. To obtain smoothness without loss of power the volume of charge must be so distributed with respect to the firing position as to obtain nearly as possible uniform acceleration in the rate of pressure rise up to the maximum rate, without excessive increase in the explosion time.

Heat Effects on Aluminium Alloy Pistons. (Ralph N. Du Bois, Automotive Industries, 19/1/29, pp. 90-94.) (10.23/10434 U.S.A.)

The pistons were fitted from the inside with 11 thermo-couples 1/16th inch below the outer surface. The combined wires from the couples were led out through a steel tube attached to the skirt and through the crankcase, along an aluminium lever to a fixed point. The measurements obtained were checked by fitting the piston with a number of fusible alloy plugs. The effects of spark setting, speed and wall temperature were investigated. It was found that the increase of piston temperature with spark advance was linear even at spark settings beyond optimum advance. An examination of all the piston heads showed that there was a cool zone apparently swept by the incoming charge extending partly around the circumference and causing the exhaust side of the piston head to run considerably cooler than the intake side. The engine was a four-cylinder motor car type, operating at speeds up to 2,000 r.p.m. and developing about 30 h.p.

2 *Lubricants and Lubrication*

The Physical Principles of Lubrication, in Particular for the Explosion Engine. (S. Kyropoulos, Z. Tech. Physik 10, 2/18, 1929.) (8.4/10435 Germany.)

Slight additions of castor oil to mineral oil produce a considerable saving of oil consumption of internal combustion engines. This is attributed mainly to decrease in the vapour pressure of the mineral oil. Oils of high viscosity produce higher running temperatures with an increase in oil combustion. The best results are obtained by using oil of medium viscosity and adding small quantities of stearic acid or castor oil.

Corrugations in Bearings and the Deterioration of Oil in Oil Engines. (E. Falz, Motorwagen, Vol. XXXII., Part 10, 10th April, 1929, pp. 205-212.) (8.4/10436 Germany.)

A descriptive account is given of the conditions under which diminution in the viscosity of the oil may render the depth of the lubricating layer less than the size of small solid particles in suspension, whereupon the latter are lodged firmly in the surface of the bearing.

Photographs of fine mesh air and oil filters are reproduced, and a micro-photograph of a special bearing metal, rich in graphite, for which tests indicate specially good results.

Lubricating Oil Specifications said to Lack Value for Car Users and Designers. (C. Edward Packer, Automotive Industries, 13/4/29, pp. 586-587.) (8.41/10437 U.S.A.)

Buying oil by specification is useless, since no specification at the present moment meets conditions occurring in practice. Such factors as gravity, pour point and flash point may be regarded as a makeshift to compensate for a large factor of ignorance.

The carbon residue test was originally developed for comparison of the carbon-forming properties of lubricating oils for internal combustion engines. It is frequently claimed that the quantity of carbon deposited in cylinders and on pistons is proportional to the carbon residue of the oil. Under ideal conditions this is probably true, but with average operating conditions, other factors such as the viscosity of the oil, the mechanical condition of the engine and the conditions of carburation of the fuel, may dominate in controlling carbon deposition.

The organic acids normally present in lubricating oil are not corrosive and have no directly harmful effects, the general quality of a lubricating oil cannot be evaluated in terms of its neutralisation number.

Determination of Oxidisability of Transformer and Turbine Oils. (N. I. Tschernoshukov, Izvestia Teplotech. Inst., Moscow, 1928, 10, 13-18.) (8.41/10438 Russia.)

Three rapid methods for measuring the asphalt and hydroxidi-acid content of oils are described. The results obtained by the Butkov test show that this method is simple and rapid and of general application for control purposes.

Recovery of Lubricating Oil. (Der Motorwagen, No. 12, April 30th, 1929.) (8.44/10439 Germany.)

After filtering off carbon and other particles, the old crankcase oil is regenerated by passing it through a layer of aluminium—magnesium—hydrosilicate. This material has the property of absorbing acid oxidation products, metal soaps and polymerisation products. It also polymerises unstable unsaturated compounds and absorbs them subsequently. The material is known under the trade name of "Floridin," and regenerators employing it have been built by Messrs. Bensmann for a number of years with success.

Properties and Analysis of Used Crankcase Oils. (D. G. Pidgeon and H. R. Tester, J. Inst. Petroleum Tech., 1929, 15, 91-99.) (8.44/10440 U.S.A.)

Distillates obtained by passing superheated steam into samples of used oils show that they consist mainly of heavy fractions of motor fuel together with cracked products of the lubricating oil. For any particular engine the percentage dilution reaches an approximately constant and characteristic value. Under certain conditions the dilution is such that a heavy grade oil is necessary at the start, in order that a safe viscosity may be reached. The amount of oxidation produced is not a function of the percentage dilution.

3 *Thermodynamics*

Carbon Monoxide from Automobiles Using Ethyl Gas. (W. P. Yant and L. B. Berger, Bur. Mines Repts. of Investigations, No. 2908, 8 pp., 1929.) (8.57/10441 U.S.A.)

Tests showed no difference in the CO content of exhaust gas when detonation was present or inaudible When running on a retarded spark there was some evidence of the CO content being less when ethyl gas was used than for straight petrol.

Flame Speeds and Their Calculation. (W. Payman and R. V. Wheeler, Fuel, Vol. VIII., No. 5, May, 1929, p. 204.) (8.57/10442 U.S.A.)

A series of experiments has been carried out in Prof. H. B. Dixon's laboratory with a number of mixtures of hydrogen, oxygen, and nitrogen of different compositions, using the original apparatus in which his experiments were carried out. These experiments have shown that the law of speeds holds for the rate of detonation in these mixtures. The law of speeds applies to the detonation wave in these mixtures for a similar, but not identical reason to that which makes it applicable to the uniform movement of flame, and only for mixtures containing sufficient oxygen for complete combustion.

The Activity of Various Catalysts in Promoting the Oxidation of Methane by Means of Oxygen. (J. R. Campbell, Chemistry and Industry, 3/5/29, Vol. 48, No. 18, p. 93.) (8.57/10443 U.S.A.)

The presence of catalysts does not affect the scheme of the course of oxidation proposed by Bone. The various stages of oxidation succeed each other very rapidly and intermediate oxidation products are not easily isolated in quantity. Of the catalysts studied (silver oxide, copper oxide, vanadium oxide, platinised asbestos, platinum black and vanadium black), platinum black proved the most effective and copper oxide the least effective.

Kinetics of the Combustion of Carbon Monoxide. (W. Kinkelstein and W. Maschowetz, Zeit. f. Phys. Chem. 138, Abt. A.6, pp. 369-378, Dec., 1928.) (8.57/10444 Germany.)

The combustion of carbon monoxide contained in glass vessels is affected by the nature of the surface of the vessel. Fresh clean surfaces act catalytically in promoting combustion. The carbon monoxide molecules coming in immediate contact with activated oxygen molecules at the surface a vigorous reaction ensues at first. The carbon dioxide produced becomes absorbed by the glass layer and thus poisons its activation. The speed of reaction thus diminishes, but can be restored by treating the surface with concentrated nitric acid.

Ignition Combustion Phenomena in Diesel Engines. (Z.F.M., 10/9/27, p. 1287, by F. Sass.) (8.57/10445 Germany.)

Evidences were found that neither gasification nor vaporisation of the injected fuel occurs before ignition; also that the hydrogen coefficient has no significance. However, the knowledge of the ignition point and of the "time lag" is important. After ignition, the combustion proceeds in a series of reactions, the last of which at least is now known. The paper has been translated in full by the National Advisory Committee for Aeronautics as Technical Memorandum No. 482.

Contribution to the Study of Flame Propagation in Gaseous Mixtures. (M. R. Duchene, Service Technique et Industriel de l'Aeronautique, Bulletin Technique, No. 54, December, 1928.) (8.57/10446 France.)

The fuel mixtures were compressed adiabatically by means of a piston and then fired by means of an electric spark. The resulting flame was photographed on a rotating film. Experiments were carried out with benzene, cyclo-hexane, cyclo-hexene and hexane. It was shown that the chemical reaction in the mixture is not completed by the passage of the flame but by adiabatic compression produced by the reflection of pressure waves. The chemical reaction proceeds in stages and the presence of tetra-ethyl lead dope renders sudden completion of the reaction by a pressure wave more difficult. The article contains original flame photographs.

The Gaseous Explosive Reaction. A Study of the Kinetics of Composite Fuels. (By F. W. Stevens, Report No. 305, National Advisory Committee for Aeronautics.) (8.57/10447 U.S.A.)

In a series of studies of the kinetics of gaseous explosives reactions the fuel under observation, instead of being a simple gas, is a known mixture of simple gases. In the practical application of the gaseous explosive reaction as a source of power in the gas engine, the fuels employed are composite, with characteristics due to the components and hence somewhat complex. The investigation of the thermodynamics or kinetics of the gaseous explosive reaction of the fuel is followed by a study of the reaction characteristics of the various known mixtures.

Studies of the Dynamics of Ignition. (O. Klusener, V.D.I., 3/11/28, p. 1580.) (8.57/10448 Germany.)

Simultaneous records of the flame position and pressure were obtained, using heptane air mixtures. The effectiveness of the shape of explosive vessel, position of igniter, and turbulence were examined. The author is of the opinion that ignition by pressure waves is quite general and occurs whether audible detonation is present or not. Only in this way can the high rates of ignition observed in engines be accounted for, turbulence alone being insufficient.

4 Carburation

Producing a Combustible Charge for Use in Internal Combustion Engines. (D. Balachowsky, P. Caire and M. Levy (B.P. 302, 717, 28/3/28, Fr. 21/12/27), Chemistry and Industry, B., Vol. 48, No. 17, 26/4/29.) (8.53/10449 U.S.A.)

The combustible charges are obtained by passing a mixture of air and petrol over a catalyst formed of one of the metals known to decompose hydrocarbons. The catalyst is heated by the exhaust of the engine, careful tension control being essential for the satisfactory working.

Combustion in Motors in which the Fuel and Air are Mixed before admitting to the Cylinder. (A. Grebel, Chimie et Industrie 20, 813-8, 1928.) (8.53/10450 France.)

The study of combustion in engine cylinders shows that with the normal type of carburettor the limit of possible efficiency is reached. In the Catalex carburettor the fuel and air are mixed in the presence of a catalyser before admission to the engine. This should lead to a further improvement in efficiency.

Investigation into the Atomisation Produced by a Jet Carburettor. (J. Souter, V.D.I., 3/11/28, p. 1572.) (8.53/10451 Germany.)

The size of the particles emitted by the carburettor are measured by a photometer. In the case of paraffin the size of the fuel particles varied from 3 to 33×10^{-3} mms.

5 Heavy Oil Engines

Diesel Engines for High Speeds. (A. Reinsch, V.D.I. 72, pp. 1371-1375, Sept., 29th, 1928.) (8.59/10452 Germany.)

Representative types of German Diesel engines operating at speeds above 1,000 r.p.m. are described. The types include both air injection, solid injection, two-stage ignition and an air storage method.

Research on the Diesel Engine, Pre-Combustion Chamber Engine. (K. Neumann, V.D.I. 72, pp. 1241-1248, Sept. 8th, 1928.) (8.59/10453 Germany.)

From a mathematical analysis of experimental results it is concluded that the combustion in the pre-combustion chamber occurs with considerable excess of air. The explosion in the chamber projects the unburned fuel into the main part of the cylinder. The temperature of the chamber and connecting passage are of the same order as the wall temperature of normal internal combustion engines. The pre-combustion type is considered to be especially adapted for the combustion of heavy oils as it is less sensitive to the possible stoppage of fuel orifices.

Packard Diesel Flown to Virginia. (Aviation, 25/5/29, p. 1803.) (8.59/10454 U.S.A.)

The Packard Diesel is a 9-cylinder air-cooled radial with an estimated weight of 3 lbs. per h.p. A demonstration of the engine was given at the Fourth Annual Conference of the National Advisory Committee for Aeronautics. A cabin monoplane, fitted with the engine, flew non-stop from Detroit to Langley Field, a distance of approximately 700 miles. The average speed was 100 m.p.h., and from the weight of fuel consumed it appears that the h.p. of the engine must be in the neighbourhood of 200.

The Acro-Bosch High Speed Diesel Engine. (Prof. R. Stribeck, V.D.I., May 28th, 1927, p. 765.) (8.59/10455 Germany.)

Experiments were carried out on an engine 120 mms. bore, 180 mms. stroke, running at speeds between 400 and 800 r.p.m. Using the method of Paterson (Forschungs-arbeiten No. 143) the temperature was measured in the combustion space of the engine under running conditions. In the Acro engine a special shaped receptacle is placed in the piston crown into which fuel is injected, at the end of the compression stroke. The whole of the clearance volume is practically in this space and the experiments show that a flame persists at the mouth of the receptacle and is fed by clean air from the exterior of the receptacle, the burnt products forming above the piston on the downward stroke. The speed of the air feeding the flame varies directly as the speed of operation, and this accounts for a constant fuel consumption per unit power irrespective of speed over the range examined. The experiments also demonstrate that the engine works on a different principle from the two-stage ignition engine and there can be thus no question of patent infringement.

The Dorner Engine. (V.D.I., 28/5/27, p. 781.) (8.591/10456 Germany.)

This engine has been taken up by the American firm of Packard. The following test figures obtained by Prof. Noyman refer to an earlier model. The engine has a bore and stroke of 95 and 160 mms. respectively. Normal operation is 1,000 r.p.m. The maximum b.e.p. obtained was 100 pounds per sq. in. with a fuel consumption of 0.46 pounds per b.h.p. hour. Plain solid injection is effected by a jug pump and a spring loaded fuel valve nozzle. The fuel pump is accurately controlled by altering the effective stroke; ports cut in the pump system are employed as inlet valves.

Combustion and its Difficulties in Marine Oil Engines. (K. O. Keller, Transactions of the North East Coast Institution of Engineers and Shipbuilders, Vol. XLV., Pt. 4, March, 1929, p. 185.) (8.591/10457 England.)

Various points are enumerated affecting combustion in internal combustion engines of the air—and airless—injection types, modes of injection, shapes of combustion spaces, methods of scavenging, with data on the velocity of the rotating air as measured on Doxford engines.

Compression Ignition Engines—their Application for Aeronautical Purposes. (M. Poincare, La Technique Aeronautique, No. 86, 15/12/28.) (8.591/10458 France.)

This French review deals mainly with the well-known German injection engines, built by Bosch, Deutz, Benz, Koerting, M.A.N. and Junkers. Amongst French engines the Tartaris, Jalbert and Rochefort are described. The Jalbert uses a carburettor for metering out the fuel. The Rochefort depends on air turbulence for injection, ignition being by means of a spark. The lead held by German designs is emphasised throughout.

6 *Two-Stroke Engines*

Improvements in Two-Stroke. (Motor, May, 1929, p. 58.) (8.871/10459 Germany.)

In the Rinne two-stroke engine the baffle plate on top of the piston is arranged to produce turbulence of the compressed charge just prior to firing. This is obtained by so shaping the combustion head that the baffle plate traps part of the charge and compresses it at a greater rate than the remainder.

Crankcase Scavenging for Two-Stroke Engine. (Dr. Ing. H. List, V.D.I., 16/2/29, p. 225.) (8.871/10460 Germany.)

The air consumption of two-stroke engines using crankcase scavenging is calculated and the result shown graphically. A method is described for determining the volumetric efficiency of such cylinders experimentally. The mean effective pressure and most favourable length of inlet ports is determined.

The Development of the Two-Stroke Engine. (Technical Notices of the Italian Air Ministry, No. 12, December, 1928, page 10.) (8.871/10461 Italy.)

This is a critical review of a series of articles which have appeared in "La Technique Automobile et Aérienne," Nos. 140, 141, 142. The importance of supercharging and scavenging is pointed out. The Fiat and Ferrara engines are described, the latter is of the U-type combustion chamber type with cylinder axes inclined. Details of oil-cooling for pistons are given.

7 *Engines, Design, Accessories, Etc.*

New Compensating Piston Supported at Top by Ring and Invar Bar. (Automotive Industries, 9/3/29, p. 418.) (8.2/10462 U.S.A.)

The design differs from conventional pistons chiefly in two respects. At the open end, the piston diameter is slightly larger in the plane of connecting rod than in the plane through the piston pin axis. At the head end, the piston bears on the cylinder wall through a cast iron ring, which is rigidly supported by a flat invar steel insert, held central with respect to the piston by being anchored at the centre of the head, and passing through slots milled at the bottom of the ring groove.

Unsymmetrical Crankshafts for V-Engines Producing Better Balance. (H. Schroen, Der Motorwagen, 30/5/29, p. 311.) (8.22/10463 Germany.)

The unsymmetrical crankshaft has the fundamental property that no forces of the first and second order or moments of the second order exist. Moments of the first order, either due to rotating or reciprocating masses can be balanced provided the angle of the V is 90°.

Torsional Vibrations of Crankshaft. (E. A. Wedemeyer, Zeitschrift fur Flugtechnik und Motorluftsschiffahrt, 28th March, 1929, Part 6, page 145.) (8.22/10464 Germany.)

A method of calculating critical periods is developed which is considered to be more rapid and certain than existing methods. A detailed calculation of a six-throw crankshaft exhibits a concise solution of the differential equation by means of a series as first proposed by Brauchitsch.

An uncertainty is introduced by the magnitude of the damping coefficient which is estimated as 0.005 kilogrammes per sq. cm. of piston area. If resonance cannot be clearly avoided vibration dampers should be fitted.

Balance of Internal Combustion Engines. (W. Kerr, Inst. Eng. and Shipbuilders, Trans. 71, pp. 693-749, Disc. 749-768, Aug., 1928.) (8.221/10465 England.)

The forces are divided into frame and shaft forces and the angle acceleration of the connecting rod is allowed for by the introduction of a special couple. The motion is expressed in terms of a Fourier series, the coefficients being determined arithmetically.

Contribution to the Stressing of Power Units for Aeroplanes. (O. Steigenberger, Z.F.M., March 14th, 1929, p. 113.) (8.24/10466 Germany.)

The forces on the crank pin and crankshaft for various types of engines are calculated and the results shown graphically. Three special cases are considered: (1) The engine running light; (2) the engine running on the normal power; (3) the aeroplane nose-diving with the engine switched off. The case of a nine-cylinder radial engine and a 12-cylinder V engine is studied in great detail.

Investigation into the Mechanics of the Fairchild-Caminez Engine. (Dipl. Ing. Zimmermann, Der Motorwagen, May 20th, 1929, page 300.) (8.89/10467 Germany.)

The Fairchild engine with a bore of 114 mm. and a stroke of 143 mm. develops 135 horse-power at 1,050 r.p.m. In the article the forces acting on the roller as well as the side pressures on the piston have been calculated and compared with those occurring in a normal five-cylinder engine of equal output. The conclusion reached is that the cam drive embodied in the Fairchild engine is not as efficient as the normal method of operation. Whether the reduction in airscrew speed inherent in the Fairchild design outweighs this disadvantage is problematic.

Long Intake Pipes may Increase Engine Output. (Automotive Industries, 13/4/29, pp. 582-584.) (8.571/10468 Italy.)

A report on an investigation into the effect of long intake pipes on engine output by the Italian writer, A. Capetti, has been translated by the National Advisory Committee for Aeronautics. The author points out that the intake pipe is traversed by a pulsating current of combustible mixture and that the phenomena of flow are quite similar to those in alternating electric circuits. Considerable supercharging may be effected by suitable tuning. The effect of a capacity in parallel to the velocity of airflow in the inlet pipe is especially marked. Capacity is placed either at the beginning or end of the inlet pipe, but gives generally little result.

Cowling of Air-Cooled Radials. (Notiziario Technico di Aeronautica, No. 3, March, 1929, p. 37.) (8.38/10469 Italy.)

In connection with the cowling described by N.A.C.A., the cowling designed by Piero Magni and fitted to a sports machine, Vittoria 1924, is described. In the Italian design, circulation through the cowling is increased by fitting a pair of subsidiary propellers inside the cowling. The spinner attached to the main propeller has the central hole through which air enters the cowling. The exit of the air through a circular flange, placed well to the rear of the engine, is in the manner of the American design.

N.A.C.A. Cowling Experiments Interest S.A.E. at Detroit. (Athel F. Denham, Automotive Industries, 20/5/29, pp. 627-628.) (8.38/10470 U.S.A.)

In attempting to apply the N.A.C.A. cowling to multi-engined aeroplanes disappointing results were obtained at first. These were traced to interference effects between the cowling and the lower wing surface. It is evident that certain precautions have to be taken, among these:—

1. The cowling and fuselage behind it must form a perfect streamline shape.
2. Frontal openings must be sufficient to admit enough cooling air for all cylinders.
3. Baffling or some form of directional air control inside the cowling must be provided to see that no air is wasted. Thus, the J-5 cowling had plates for the magnetos and deflectors near the rocker arm boxes, which required no cooling.

500 *h.p. Panhard Sleeve Valve Engine.* (L'Aerophile, March, 1929, p. 81.) (8.561/10471 France.)

The engine is a 12-cylinder V with a bore and stroke of 140 and 170 mms. Its normal speed is 1,700 r.p.m. and the weight approximately 1,000 pounds. Two steel sleeves are used per cylinder.

Centrifugal Oil Cleaner. Contribution towards the Problem of Cleaning Engine Oil. (W. Schwerdtfeger, Der Motorwagen, 20/4/29, p. 234.) (8.44/10472 Germany.)

A centrifugal type of oil cleaner is described which is worked by the oil flow direct without the interposition of gearing. The pressure drop is of the order of one atmosphere, microscopic examination of the oil has revealed the absence of all particles in excess of 1/500th mm. diameter.

Supercharging of I.C. Engines. (C. Waseige, La Technique Aéronautique, No. 89, 15/3/29, p. 42-62.) (8.62/10473 France.)

The Rateau centrifugal single-stage fan as adopted by Farman runs at 20,000 r.p.m., a centrifugally loaded friction clutch being interposed between the engine and the step-up gears. When out of action the blower is driven at engine speed and absorbs under these conditions about five horse-power. The fan thus accelerates not from rest but from 2,000 r.p.m., the normal engine speed. If at rest, when not in use, it would throttle the engine intake excessively. If declutched, but rotated by the air taken, it would absorb about 35 horse-power. If driven at full speed and throttled at intake the power consumption amounts to over 80 horse-power. The Farman solution of the problem thus amounts to providing a two-speed gear. For efficient working a third speed should be provided. The power consumption at 5,000 metres is 80 h.p. From the quantity of air delivered and the temperature rise, the Farman blower has an adiabatic compression efficiency of approximately 50 per cent. The weight of the installation is given as 107 lbs.

Automatic Ignition Advance on Scintilla Magneto. (Der Motorwagen, No. 12, April 30th, 1929.) (8.91/10474 Switzerland.)

A centrifugal device is incorporated in the inductor of the magneto and causes an advance of the spark burning with speed. The dimensions of the magneto are not affected by the device, which has now given satisfactory service for several years. The makers are the well-known Swiss firm, Scintilla, of Solcure, whose magneto has practically become standard in U.S.A.

Engine Cooling Fluid Developed by the United States Army. (Aviation, 30/3/29, p. 965.) (8.331/10475 U.S.A.)

Tests carried out with a fluid other than water as the cooling medium in engine radiators has resulted in a saving in weight of over 120 lbs. Instead of the usual 18 gallons of water only 4½ gallons of the chemical are required, this alone resulting in a saving in weight of over 80 lbs. The additional saving in weight is due to the possibility of using a smaller radiator. The fluid has a boiling point of 200°C. and further details are promised by the Secretary for War of Aviation.

High Temperature Cooling Agent Found in Ethylene-Glycol. (Edmund B. Neil, Automotive Industries, April 13th, 1929, pp. 597.) (8.331/10476 U.S.A.)

Experiments have been carried out recently by the American Government with a new cooling agent, the composition of which at first was not divulged. It is now known that ethylene-glycol was used, a substance which has been known

as an anti-freeze for several years. The boiling point of this substance is approximately 200°C. Its specific heat is roughly two-thirds that of water and its density 1.114. It is stated that by the use of this substance a considerable saving in the weight of the power plant can be effected. Part of this saving is due to reduction in the size of the radiator required, the remainder is due to the smaller quantity of cooling fluid necessary.

AIRCRAFT DESIGN

8 *Aerodynamics and Hydrodynamics*

Aerodynamics and Hydrodynamics. Double Row of Vortices with Arbitrary Stagger. (L. Rosenhead, Proc. Camb. Phil. Soc., Vol. XXV., Part II., 1929, pp. 132-138.) (5.32/10477 England.)

The author examines, generally, the conditions of equilibrium and stability for all possible arrangements of two parallel rectilinear rows of equal and equally spaced vortices, the signs being different in the two rows.

The eliminant is formed of the four arbitrary constants in the linear differential equations obtained by assuming *initial* equilibrium, and it is shown that v. Karman's arrangement alone is in neutral equilibrium and that of the other possible arrangements the symmetrical one alone is in unstable equilibrium.

(The argument does not appear to be entirely consequent, but the results are no doubt correct for two-dimensional disturbances.)

Benard's Alternate Vortices in a Channel of Finite Dimensions. (H. Villat, Comptes Rendus, Vol. 188, No. 18, 29th April, 1929, pp. 1129-1132. (5.32/10478 France.)

v. Karman's criterion of stability is written down and transformed to take into account the repeated reflections which divide the whole plane into a network of equal rectangular meshes. The velocity field is now expressed in zeta elliptic functions, the periods of which are given by the sides of the mesh.

The stream function is given in terms of sigma functions and the resistance of the cylinder in terms of zeta and Weierstrassian functions, the periodicity of the stream function giving a relation of immediate practical importance.

When the walls are taken to a distance the expression for the resistance approaches a limit differing from v. Karman's result. This is due to the fact that the stream functions at the boundaries have now a finite difference of value. The physical explanation is that walls, even at a large distance compared with the width of the vortex street, impose the condition of equal inflow and discharge on the canalised stream, which is absent in an indefinitely great mass of fluid.

A comparison with experiment is to follow.

Influence of the Shape of the Nose of Blade Profiles of Centrifugal Pumps on Cavitation. (H. Pöter, Z.F.M., Vol. 9, Part 2, April, 1929, pp. 85-101.) (5.33/10479 Germany.)

The problem is considered in its two-dimensional form. The surface of the blade at the nose is replaced by a linear distribution of sources and the effect on a velocity field calculated in the usual way. The distance from the nose of the point of maximum pressure drop is calculated for a variety of cases and exhibited in a table.

The drop of pressure is also exhibited as a function of the curvature for blades of equal chord and thickness, but with five shapes of nose rounded off in different manners.

Conclusions are drawn as to the most suitable type of nose to avoid cavitation.

Full-Scale Tests on a Thin Metal Propeller at Various Tip Speeds. (F. E. Weick, National Advisory Committee for Aeronautics, Report No. 302.) (5.421/10480 U.S.A.)

An investigation was made to determine the effect of tip speed on the characteristics of a thin-bladed metal airscrew mounted on a VE-7 airplane with a 180 h.p. E-2 engine, and tested in the 20-foot research tunnel. The effect of tip speed on the efficiency was negligible within the range of tests, from 600 to 1,000 ft. per sec. (about 0.5 to 0.9 of the velocity of sound in air).

Aerodynamics of Wings. (Anon. Revue Generale de L'Aeronautique, Vol. 10, 1929, pp. 1-112.) (5.31/10481 France.)

The article is a useful exposition of Joukowsky's theory of profiles, of Prandtl's exposition of the physical causes of circulation and of developments by v. Mises, Betz, Munk and others.

Some Problems Confronting Present Day Aerodynamics. (Dr. H. Blenk, V.D.I., Oct. 8th, 1928, p. 1395.) (5.3/10482 Germany.)

The requirements of safety and efficiency, unfortunately, oppose one another. Mutual wing interference in a biplane is fairly well understood. Interference between the wings and the tail plane, between the wings and the body, between the airscrew and the aircraft as a whole remain obscure. Experiments are wanted with aerofoils of various profiles at speeds exceeding the velocity of sound. Structural resonance may be due to the equality of the free period of some part with the period of the engine or of eddies thrown off. Wing flutter may be produced by the inter-action of restoring forces due to torsion and bending and disturbing forces depending on the incidence. During recent gliding experiments many examples of wing and tail flutter were studied and the various methods of eliminating them are described. A fairly extensive bibliography is given.

Results of Gliding Competitions in 1928. (W. Georgii and A. Lippich, Z.F.M., Vol. 20, P. 3, 14/2/29, pp. 57-70.) (5.322/10483 Germany.)

An analysis is given of the French gliding competition at Vauville near Cherbourg, July, 1928, and of the Rhön competition August, 1928. Contour maps are given of the surrounding country and indications of the prevailing winds. The performance of the German competitors is given in considerable detail, as to times and distances flown without landing, a flight of 29 kilometres by Hierth being noteworthy.

Much more extensive analysis is given of the German competition in the Rhön valley, the contour lines, the plan of the flights, the barograms, the effects of cumulus clouds, etc., being exhibited graphically.

A second technical account by A. Lippich gives photographs and dimensioned sketches of competing gliders along with formulæ used for reductions and polar diagrams.

Displacement Resistance. (H. Lorenz, Z.F.M., Vol. 20, P. 6, 28/3/28, pp. 141-143.) (5.32/10484 Germany.)

An analysis of the body resistances is attempted but it is difficult to find any new physical principle in spite of novel terminology.

The Critical Length of Aeroplane Wings. (J. Mather, Report from Aerodynamical Institute, Aachen, Z.F.M., Vol. 20, P. 6, 28/3/29, pp. 143-145.) (5.211/10485 Germany.)

Applying the usual methods of analysis for forced vibrations the author finds that there is a critical length at which vibration sets in which is related to the

loading, the bending stiffness, the distance between the spars, and the torsion in a definite manner. Some of these relations are given graphically.

Slotted Wings. (Automotive Industries, 20/4/29, p. 628. C. B. Harper, Bureau of Aeronautics.) (7.6/10486 U.S.A.)

The installation of a slot on any new airplane requires a great deal of "tailoring" and research in order to obtain maximum effectiveness; with high lift airfoil sections the gain of control effectiveness after the stalling point has been reached for the normal wing is not so pronounced.

In the work of the navy on this subject, a "spoiler" flap working in conjunction with the aileron control has proved rather effective. The flap is built into the upper wing side just back of the top of the camber. In operation, the rear edge of the flap swings upward and forward about the front edge, "spoiling" the air flow over the wing and assisting the aileron in dropping that wing.

Suggestions for Apparatus, etc., for Teaching Elements of Aerodynamics in Schools. (Dipl. Ing. C. Boving, Luftfahrt, No. 8, 22/4/29.) (11.11/10487 Germany.)

A small scale wind channel of the open flow type operated with a 2 h.p. electric motor renders possible a series of fundamental experiments in aerodynamics. A simplified two component balance is described and methods are given for making model profiles of various sections.

Apparatus for Measuring Aerodynamical Velocities Round an Aeroplane. (E. Huguenard and A. Magnan, Comptes Rendus, Vol. 188, No. 7, 11/2/29, pp. 484-487.) (11.15/10488 France.)

The apparatus consists of two Pitot tubes of the same type placed at different positions but connected to a differential monometer with a quick reading needle, recording the differences on a rotating cylinder.

The instrument has been used for exploring velocity round an aeroplane. It can also be used to determine the rotations of the airscrew which produce no effective wash for a given aeroplane speed, the null point being indicated by zero reading of the manometer needle.

In the latter measurements one Pitot or Venturi tube is placed outside the influence of the screw and the other behind it. Further details of the mounting are given.

Combined Lateral and Longitudinal Oscillations of an Aeroplane. (A. v. Baranoff and L. Hopf, L.F.F., Vol. 3, Part 2, 20/3/29, pp. 39-58.) (7.21/10489 Germany.)

The problem considered is the general motion about mean steady flight produced by the action of the rudder.

After references to previous work, the authors select suitable axes and write down a number of formulæ of transformation for angular movements, for forces and moments, and for steady motion, in the usual way.

To assist the computations a graphical chart is prepared of the forces in the form of a diagram of incidence and a function of centrifugal forces about the vertical axis, for constant values of time and yaw, giving two families of curves on the same diagrams.

In a similar manner a family of curves of rolling moment coefficients is plotted as a function of the resolved motions of the wing tip for different constant values of the incidence, about the three axes. The rolling moment is also plotted as a function of the yaw angle. A further diagram gives the yawing moment as a function of the resolved wing tip velocity about the flight axis.

A series of diagrams is drawn exhibiting families of curves corresponding to different incidences plotted on the plane of which the co-ordinates are the resolved

wing tip velocities about the path axis and the lift axis, each point representing equilibrium of the rolling moments without rudder reaction. Figure 15 shows lines of equilibrium of forces in the same co-ordinates.

Using the same co-ordinates figure 16 shows the line of equilibrium of moments which is nearly straight cutting the line of equilibrium of forces which has an inflection in three points at which both forces and moments are in equilibrium.

Reverting now to the co-ordinates, inertia forces (of rotation) and incidence, three curves of equilibrium of both rolling moment and forces are exhibited for three different settings of the rudder.

The next figure gives graphically in the same co-ordinates as the last the general graphical representation of the conditions of equilibrium for forces and moments.

With the aid of the relations established the author discusses curved flight and the transition to spiral flight and finally to spin, and the relations on coming out of the spin, all of which are exhibited graphically.

The analysis shows the dependence of symmetrical and unsymmetrical movements of stability for finite movement, which produces such complications that only the numerical study of particular cases is possible.

These show however the nature of the mutual influences of the motion on the different displacements, the derivations of which with respect to time appear as functions of the displacements themselves and of constructional constants.

The possibility of the spin depends on two comparatively simple quantities, the square of the velocity divided by the span and the loading per unit surface multiplied by the difference of the squares of the radii of inertia and divided by the product of span and chord. The most effective method of overcoming a tendency to spin appears to be an alteration of the moments of inertia by a new distribution of masses, but this method has not yet been sufficiently explored.

A further effective method is power of directional control which keeps the side wind within small limits.

Numerical examples show how sensitive the conditions of entering and leaving a spin are to particular numerical values of roll and yaw, and how they may differ for the same values in different phases of the motion.

9 *General Design*

Variable Area Wing Aeroplane. (Automotive Industries, 9/3/29, p. 406.) (5.33/10490 U.S.A.)

An auxiliary wing is placed centrally behind the main wing, forming an extension thereof, in normal flight withdrawn under the main wing. From the test figures supplied the device increases the top speed by about 10 per cent. and diminishes the landing speed by about 5 per cent.

Recent Measurements of Characteristics of Wings with Parts Cut Away. (H. Muttray, Göttingen, Report of the Kaiser Wilhelm Aerodynamical Institute, Z.F.M., 15th April, 1929, Vol. 20, Part 7, pp. 161-169.) (5.33/10491 Germany.)

The Greif Glider, the Avimeta Fighter and the Westland Widgeon III., sporting monoplane, are examples of aeroplanes with a marked cutaway of the wings.

Before describing the new experiments on models lengthy extracts are given from the 3rd issue of the Göttingen reports (Air Ministry Notices and Abstracts No. 7).

The experimental work was carried out in the 2.24 m. diameter channel with a wind speed of 30 m/s. on wings of 20 cm. chord, 100 cm. span. A systematic series of four cut-aways was made from the leading edge or the trailing edge or both. The polars of the four models are plotted in the same chart.

The important fact is established that by shaping the central section so as to maintain approximately constant lift distribution along the span, the polar differs very little from the uncut wing, the fixed vortex lines running continuously from tip to tip but becoming crowded at the partially cut-away section.

Where this is not done the distribution of lift falls off at the cut-away, and the polars show signs of diversion of the stream within the flying range.

A second series of measurements was made on thick wings with high maximum lift, the connecting portion across the cut-away having a still higher maximum lift coefficient and with 10° higher incidence.

An auxiliary wing was fitted to the central section forming a slot in the leading edge, and was tested with and without end shields, in the latter case the polar of the original wing being very nearly attained throughout the whole flying range.

In the third series of tests the central section was cut out and slid forwards or backwards along the chord. The characteristics were adversely affected to an appreciable degree near the stalling point.

Compressed Air Brakes for Landing Carriages. (T. H. Kollinck, Luftfahrt, 7th March, 1929, p. 71.) (5.55/10492 Germany.)

A compressed air brake has been developed by the firm of Knorr, who are specialists in brakes for railway trains. The air is furnished by a small piston compressor driven either by the engine direct or by means of a separate propeller. Normally the brakes operating the two halves of the landing gear are accurately balanced but for steering purposes the pilot can lock one or other wheel. The apparatus has been tried on a Junkers machine and reduces the landing run by two-thirds. It was possible to turn the machine on the ground on one wheel.

Test Flights of Rohrbach "Romar." (Flugsport, 6/2/29, No. 3.) (4.14/10493 Germany.)

The German ministry of aerial transport subjected the Rohrbach "Romar" to seaworthiness tests early in December, 1928. The useful load carried varied between three and eight tons, the total weight of machine and load reaching almost twenty tons. The tests proved generally successful with the exception of partial failure of the right wing float. Had it not been for the water-tight construction of the wings, which is a special feature of the Rohrbach design, the machine would probably have become a total wreck, as it was it reached port under its own power and the float was repaired.

MATERIALS

10 Metallurgy

Carboloy—A New Tool Material. (S. L. Hoyt, Gen El. Rev. 31, pp. 585-591, Nov., 1928. Paper read before the Annual Convention of the Amer. Soc. for Steel Treating, Philadelphia, Oct., 1928.) (10.6/10494 U.S.A.)

A new alloy of cobalt and tungsten carbide has been produced by the Research Laboratory of the G.E.C. This alloy has a density of approximately 14 and is characterised by extreme hardness. It will scratch natural sapphire and will cut a deep groove in an alundum wheel. The material has been given the name of Carboloy.

Applications of Chromium Plating. (W. Blum, Mechanical Engineering, 50, pp. 927-930, Dec., 1928.) (10.27/10495 U.S.A.)

The chief limitation in the use of chromium for plating is its liability to flake when deformed. Deposition on cutting tools has been successful only in certain cases, and its general application to engine parts which are subjected to strains awaits further improvement in technique.

11 Corrosion

Methods of Testing Resistance of Metals to Corrosion by Weather and Sea Water. (E. Rackwitz and K. O. Schmidt, Zeitschrift fur Flugtechnik und Motorluftschiffahrt, 28/3/29, No. 6.) (10.15/10496 Germany.)

The article is a plea for standardisation of methods for testing corrosion especially of light alloys. The various standard methods employed by the D.V.L. are described in detail. The method specially favoured by the author consists in determining the ultimate tensile and extension of the specimen both in the normal and corroded stage. Provided suitable precautions are observed as to the place in the corroded specimen from which the test piece is cut a satisfactory agreement between the progress of corrosion and the change in mechanical properties can be traced.

Corrosion of Aluminium. (J. Calvet, Comptes Rendus, T. 188, No. 11, 22nd April, 1929, pp. 1111-1161.) (10.27/10497 France.)

Extra pure aluminium by Hoopes' process, 99.95 per cent. Al., shows far less corrosion than pure aluminium, 99.75 per cent. Al., and ordinary aluminium, 99.2 per cent. Al., under test with variety of acids.

A Problem in Protective Coatings. (F. N. Speller, Industrial and Engineering Chemistry, Vol. 21, No. 5, pp. 500-510.) (10.27/10498 U.S.A.)

Corrosion is determined and controlled by influences external to the metal, which either form or destroy surface films on the metal.

Protective films form more readily in air than in water or soil.

Where the metal is continuously in contact with soil or water, commercial steel or wrought iron suffers about the same under the same conditions of exposure irrespective of method of manufacture or the amount of foreign material present within wide limits.

When exposed in air, however, copper in amounts over 0.15 per cent. has a marked effect in forming a stable surface coating of oxides which increases the life of the metal at least two or three times. This is the result of tests in service extending over a period of more than ten years. There is no such evidence as yet that other additions give additional life.

For highly corrosive conditions where the first cost of metal is not of prime importance, suitable metals are now available, such as the 18 per cent. chromium —8 per cent. nickel alloy, but in selecting the most economical alloy for any particular purpose it is important first to study the environment and select a metal that contains the elements that will be most likely to form a stable surface film under conditions of service.

Tests of Methods of Protection Against Corrosion by the Atmosphere and by Sea Water. (E. Rackwitz and K. Schmidt, 127th Report of D.V.L., pp. 137-141.) (10.27/10499 Germany.)

An account is given of the installation and methods of test in the materials section of D.V.L. Laboratory, Berlin-Adlershof, illustrated by 10 diagrams and photographs. The article is entirely descriptive.

12 Composite Materials

Micalex. (A. E. G. Mitt, No. 12, pp. 629-631, Dec., 1928.) (10.59/10500 Germany.)

The A.E.G. have introduced a new moulded insulating material called Micalex. The material can be moulded on to metal. Illustrations are given showing numerous applications.

MISCELLANEOUS

13 Instruments

Automatic Pilot. (Les cahiers techniques du comité français de Propagande Aéronautique. Supplement to Les Ailes, No. 401, 21/2/1929.) (7.4/10501 France.)

The automatic stabiliser is built by Messgeräte Boykow G. m. b. H. and controls the rudder, the elevator, and the ailerons. The firm also constructs an artificial horizon, the action of which depends on the frictionless precession if a gyroscope. The stabiliser has been fitted to a Junkers machine and its action favourably commented on by Mr. Köhl, of Atlantic fame.

A New Vibrationless Method of Mounting Delicate Instruments. (R. Muller, Annalen der Physik, No. 5, 1929, pp. 613-657.) (6.37/10502 Germany.)

A critical review shows that the suspension Julius gives satisfactory results in most cases. The underlying principles of this method are investigated, and improvements carried out. These depend on the following three principles: (*a*) No attempt is made to weaken the vertical component of the vibration; (*b*) the period of translatory vibration in a horizontal direction is made very large; (*c*) a new form of damping is employed, using a liquid of suitable viscosity.

Chronograph, marking 1/10,000 sec. (P. Lejoy, Comptes Rendus, No. 17, T. 188, 22nd April, 1929, pp. 1089-1091.) (6.48/10503 France.)

The pendulum alters a capacity in a circuit with an amplifier. The emitted signal is amplified, and causes the movement of a spot light with a velocity of 120 cm./sec.

All the elements of the apparatus are ordinarily available in a laboratory.

Examination of contact pendulums shows a relative fineness of subdivision of 1/10,000 sec. to 1/1,000 sec. in favour of the capacity pendulum.

14 Wireless

D./F. Apparatus on Aircraft. (126 D.V.L. Report concld., Zeitschrift fur Hochfrequenztechnik, No. 4, April, 1929, p. 132.) (13.4/10504 Germany.)

The new direction finding apparatus designed by Telefunken Mk. 173N is fully described. Flight results obtained by this apparatus are given, showing the relation between the angular minimum zone and the distance from the directional station. Using both compass and directional wireless a mean total error of 5 degrees between the true and calculated course was obtained.

Ignition Shielding for Radio Operation. (Lawrence A. Hyland, Aviation, 23/3/29, Vol. XXVI., No. 12, p. 886.) (13.6/10505 U.S.A.)

Practically all the early shielding efforts were conducted on the Liberty engine, which has a notoriously weak ignition system. If an additional capacity were introduced in the form of a tight metal shield over the individual wires, too much energy was diverted and the spark in the plug became uncertain. A high tension magneto of modern design has a large power reserve and the added capacity of the wire due to the shielding results in a hotter spark. Radial interference can only be prevented if the sparking plugs themselves are shielded. Prior effects of shielded plugs had lacked the necessary electrical insulating and heat radiating properties essential in modern high compression engines. The Naval Research Laboratory of the U.S.A. have developed a shielded plug which was completely satisfactory in practice. On account of the largely increased radiating surface this plug will offer entirely new possibilities for cooling. It is confidently expected that aircraft receiving performance will shortly be comparable to that obtained on the ground with heavier and bulkier equipment.

Measurements with Short Wave Tubes. (H. Hornung, Ann. d. Phys., 1929, Vol. I., Part 4, pp. 417-456.) (12.7/10506 Germany.)

The paper is supplementary to the investigation on short wave lengths (under 1 metre) carried out by K. Kohl.

Diagrams exhibit the types of valve used and the connections.

The wave length depends principally on the magnitude of the small oscillating circuit of the valve, which is bridged by the grid-anode capacity and their connections. With increasing flow of electrons at constant anode and grid voltage the wave length falls off in linear relation. With increasing grid voltage and constant anode voltage and electron stress the wave length falls off in linear relation. With increasing anode voltage and constant electron stress and grid voltage the wave length increases almost in linear relation. The shortest wave length observed was 30 cm.

15 Bomb-Sighting

Investigation of Bomb Trajectories. (Giavanni Bruno, Technical Notices of the Italian Air Ministry, No. 1, January, 1929, page 27.) (9.5/10507 Italy.)

The effect of variation in wind speed angle of inclination, etc., is shown by means of worked out examples.

Recent Development in Aircraft Armament. (Capt. R. C. Coupland, Aviation, 5/1/29, p. 33.) (9.5/10508 U.S.A.)

Improvement in the accuracy of bombing has been brought about by consideration of the following points:—

(1) Stabilisation of the aeroplane proper;
(2) Stability of the bomb sight;
(3) The accuracy of the director equipment;
(4) The mechanical releasing apparatus for the bombs;
(5) Flying characteristic of bomb.

One of the latest types of bomb sights used in the American Army is illustrated (Mark D.4). The airplane is directed on its course by the bomber using a synchronized indicator, or pilot director, operating directly and automatically from the sighting equipment. To correct for wind velocity, angle of approach, speed of target and the speed of bomber, it is a question of referring the angular velocity to a constant speed device. The difference in speed of the two elements controls a sight reference point, which is in turn calibrated in such a manner as to give the proper corrections for the known ballistics of the bomb.

In the D.4 bomb sight the constant speed device is an escapement mechanism similar to a clock. The velocity of angular travel is obtained by manipulating a hand crank. There is a hand adjustment for altitude and the variations of bomb ballistics due to the types and sizes of bombs concerned. Several developments are under consideration.

16 Meteorology

The Transfer of Heat by Radiation and Turbulence. (D. Brunt, Proc. Roy. Soc., A. 124, No. 793, 2/5/29, pp. 201-218.) (6.23/10509.)

In applying the mathematical theory of stability to the atmosphere it has been pointed out in recent years that the thermal conductivity determined by the kinetic theory is negligibly small.

It has, therefore, to be replaced by a symbol representing the effective transference of heat. The author follows up the suggestion, due to Helmboltz, that radiation and absorption are responsible for the transfer of heat on a much larger scale than molecular conductivity and finds a coefficient K_R which he calls the

radiative diffusivity, of an order reaching 1.3×10^3. The corresponding coefficient for molecular conduction is about 0.17 in the same units.

Prof. G. I. Taylor has introduced an eddy coefficient K which can only be determined experimentally from each particular case, and which has been observed with a value as high as 10^5 during the day, but in inversions at night is of the order of 10^3. During unstable day-time conditions K is of more importance than K_R. None the less K_R must have a large effect in determining the initial type of instability.

Following G. C. Simpson, it is demonstrated that water vapour has a decisive effect in determining K_R.

Temperature measured by thermometer is the most convenient variable in discussing transfer of heat by turbulence and not the so-called potential temperature, which has been used in a number of previous papers on the subject.

Taylor's original discussion (Phil. Trans. 1915) was for incompressible fluids. The author extends these results to a compressible fluid.

The paper is an important addition to the comparatively small body of results on the instability of a viscous fluid unequally heated.

17 Towed Flight

Towed Flight. (A. Lippisch, Z.F.M., Vol. 20, P. 3, 14/2/29, pp. 71-74.) (15.22/10510 Germany.)

A method is given for reducing the results obtained by towing a glider behind a power-driven aeroplane.

In addition to the usual variables, the direction and tension of the towing line is observed, and the lift and drag are deduced by elementary methods.

The separation of the lift and drag of the two aircraft is carried out and the results are exhibited graphically in 9 diagrams.

18 Fire Prevention

Aviation Fire Prevention in the Navy. (Lieutenant Commander C. G. McCord, U.S.N. Member, Superintendent of Tests, Naval Aircraft Factory, Journal of the American Society of Naval Engineers, Vol. XLI., No. 2, May, 1929, p. 239.) (16.12/10511 U.S.A.)

The apparatus tested by the Navy and War Departments emitted either carbon tetra chloride or carbon dioxide snow and gas. Two types of engines were employed with each type of extinguishing apparatus, one a radial and the other a V type. The engines were literally drenched with petrol, and the fire fanned by a propeller placed in the vicinity. A satisfactory extinguisher of the carbon dioxide type weighed 52.5 lbs. complete.

AERONAUTICAL RESEARCH IN SWEDEN

BY

TORD. K. ÅNGSTRÖM, CIVIL ENGINEER, K.T.H.,

SECRETARY TO THE SWEDISH AERONAUTICAL COMMITTEE

(*A Paper read before the Society at Olympia, July 20th*, 1929.)

This paper contains a report on the principal aeronautical research work carried out by the Aeronautical Committee of the Royal Swedish Institute for Scientific Industrial Research.

The Royal Swedish Institute for Scientific Industrial Research in 1925 appointed an Aeronautical Committee with the object of promoting scientific technical research work and general development work in the field of aeronautics. In the first place work has been concentrated on such problems in aeronautics which are of particular importance with regard to special Swedish conditions.

The Aeronautical Committee has been concerned in establishing an aeronautical chair, combined with an aeronautical laboratory, at the Royal Technical University in Stockholm. The aeronautical professorship is now established by Parliament, and a professor will shortly be appointed. The establishment of the aeronautical laboratory has been postponed for the present, but there is hardly any doubt that the laboratory will be in being within the next few years.

During the past years the Aeronautical Committee has had the advantage of having the Governor, the present Cabinet Minister, Sven Lübeck, as Chairman, and the Director of the Swedish Institute for Scientific Industrial Research, Professor Axel Enström, as Vice-Chairman.

To enable the Committee to carry out aeronautical research work in accordance with a three years' programme, smaller yearly grants have been allotted. This work is carried out and conducted by different members of the Committee, who do not receive any remuneration for their work.

The aeronautical research work in question deals with six main subjects, viz. :—

(1) Wood for aeroplane construction.
(2) Corrosion and fatigue of metals and alloys.
(3) Steel construction.
(4) Special engine problems.
(5) Aeroplane floats.
(6) Skis.

Research work on material and construction has been conducted by the Chief of the Government Testing Institute of Sweden, Professor Roos af Hjelmsäter, and the investigations into engine problems by Professor Hubendick, of the Royal Technical University in Stockholm

Research Work on Wood

The research work on wood has been concentrated on the stock-taking of Swedish supplies of such wood which can be used in aeroplane manufacture, as well as on an investigation into the strength properties of the Swedish wood.

The substitutes for American spruce which can be obtained in the country are Swedish pine and Swedish fir. The investigations into the possibilities of obtaining within the country sufficient quantities of wood of a quality which will satisfy the comparatively high aeronautical requirements have been carried out by Mr. Georg Spaak, civil engineer. Spaak has examined different methods of selecting material and has come to the conclusion that the only practical method is to select on the spot, where it grows, wood which from outward appearance appears to fill the requirements with regard to quality. A similar method also seems to have been in use in America. The possibilities of obtaining a material sufficiently free from knots are far more favourable in the case of fir than pine and it may be said that only fir can be taken into consideration when there is a question of obtaining really large quantities.

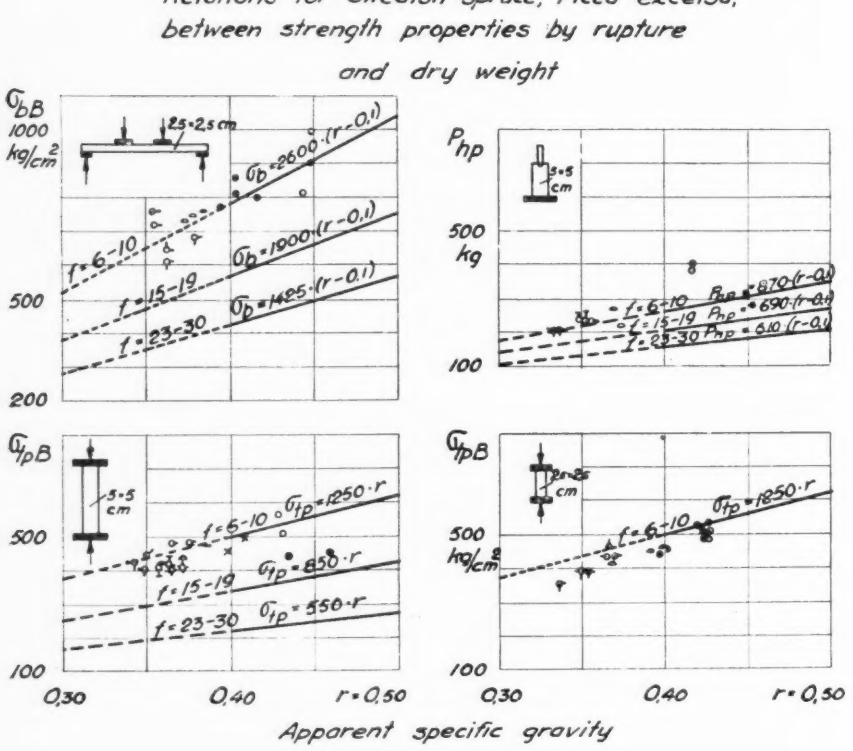


FIG. 1.

Compression and bending strength by rupture as well as hardness (Php) of Swedish whitewood timber (Swedish spruce, Picea excelsa), and its dependence on the specific gravity r at a moisture content of f equalling 12 per cent. of the dry weight (single dots). For comparison, lines have been inserted with equations for the corresponding properties of Swedish redwood timber (Swedish pine, Pinus silvestris) at various moisture contents. The compression strength has been determined with the same result partly with standard test specimens (5 × 5 × 20 cm.) and partly with aeronautical test specimens (2.5 × 2.5 × 5 cm.).

The fundamental strength properties of Swedish wood have been determined through extensive investigations at the Government Testing Institute of Sweden by Mr. R. Schlyter, civil engineer. The results obtained have been compiled in the attached diagram (Fig. 1).

The Aeronautical Committee has considered the fatigue properties to be of special importance with regard to the possibilities of estimating the suitability and value of different materials for construction. This kind of stress ought to be more considered in aeronautics as in many cases the static strength properties are not sufficient to determine the safety attained with the material. Here we cannot enter into the question of the degree to which the fatigue strength of the material must be taken into consideration in aeroplane construction. It should, in this connection, be sufficient to bear in mind that most of the constructional elements of an aeroplane are subject to comparatively great variations in strain. Although evidently the ultimate fatigue strength is arrived at only in few of these cases a glance at the fatigue diagram shows that the strength on a static

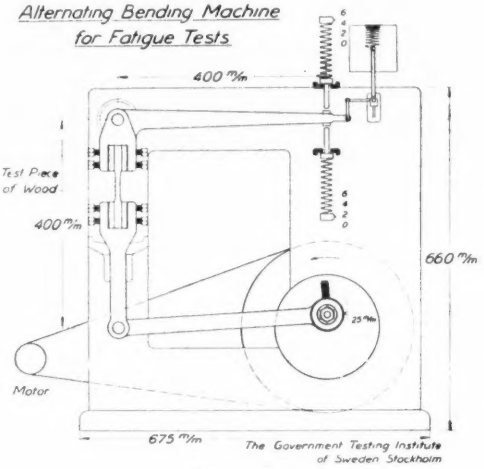


FIG. 2A.

test is subject to a considerable reduction even in the case of a comparatively small number of changes in stress. Especially in the case of wood, the knowledge of the fatigue limit has been extremely imperfect. Now, however, there are in hand results from the fatigue investigations which have been carried out by the Aeronautical Committee in conjunction with the Government Testing Institute of Sweden in the case of Swedish pine, Swedish fir and American spruce. A special fatigue testing machine has been designed for the purpose (Figs. 2A and 2B). The machine gives alternating bending stresses. Determinative of the fatigue limit in this case is evidently the compressive strength of the material, and it has been found suitable to indicate the fatigue limit as a percentage of the pure compressive strength of the wood material. From the diagram (Fig. 3) it appears that the fatigue limit for the woods under test amounts to 40-45 per cent. of the corresponding compressive strength.

The Aeronautical Committee also intends to extend these investigations to include the influence of smaller defects in the material and the influence of glued joints. These investigations should be completed within the next year.

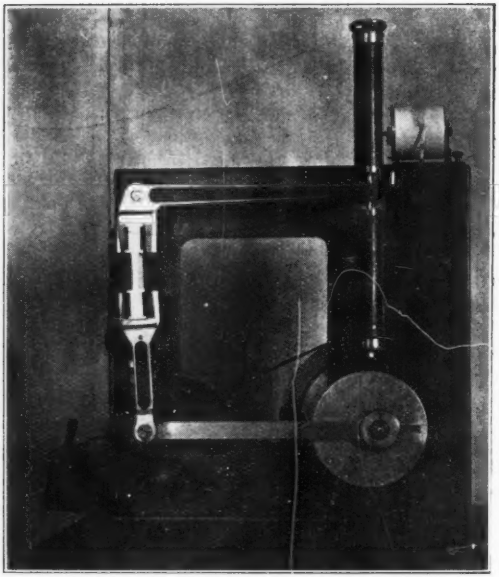


FIG. 2B.

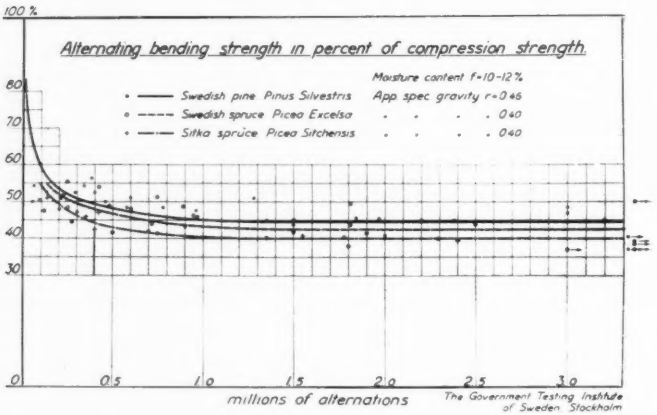


FIG. 3.

Corrosion and Fatigue of Metals

So far these investigations have been concentrated on a determination of the strength properties of steel and duralumin with regard to corrosion and fatigue.

The writer in 1922-23 started systematic research work on the influence of corrosion on the strength properties of duralumin and steel. During the first tests a very simple method was used, but the results obtained were of consider-

able interest, and they have, in all essentials, been confirmed by similar investigations which have been carried out in America, Germany and other countries.

In his tests the writer used a number of test pieces cut from sheets of steel and duralumin, which were lowered below the surface of a 3 per cent. salt water solution. In some cases the whole of the test piece was lowered, in other cases one half of it. After lapse of a certain time a number of the test pieces were taken out and tested for their strength properties; after additional time this

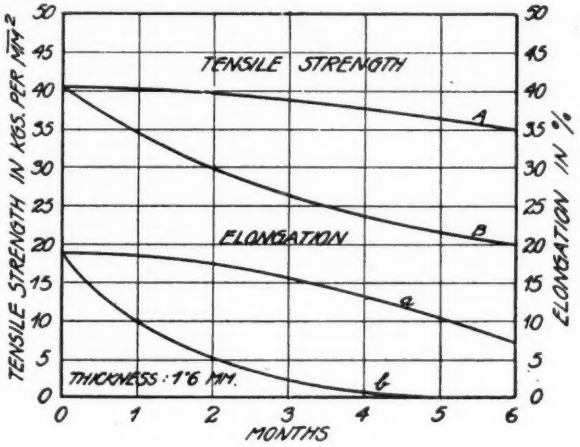


FIG. 4A.
Duralumin.

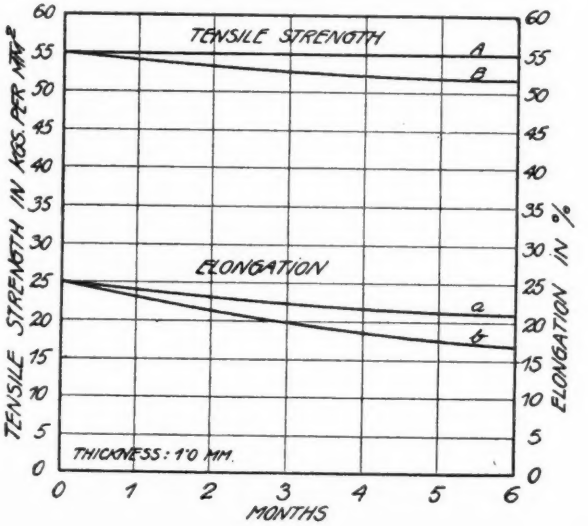


FIG 4B.
Steel.

process was repeated, etc. In this way it was possible to study the influence of the corrosion process on the strength properties. The results, which were published in 1924, indicated the change in strength properties of duralumin, which is noticed in Figs. 4A and 4B. They made also evident to what a high degree corrosion is dependent on the supply of oxygen from the air. The simplicity of

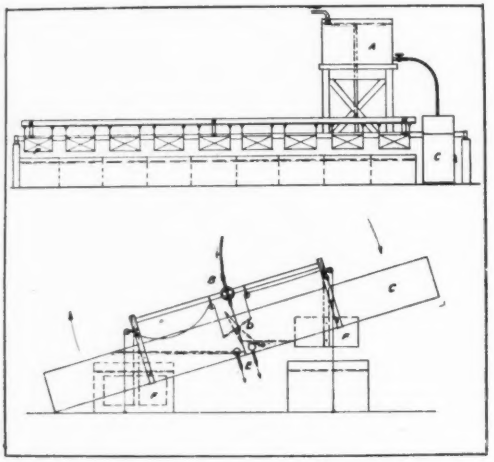


FIG. 5A.

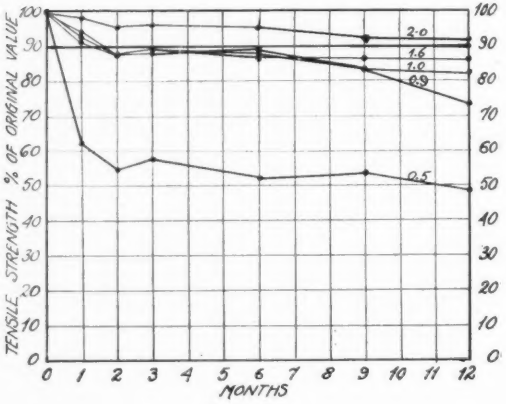


FIG. 5B.

Influence on unprotected duralumin with different thicknesses.

the method here outlined makes it well worth consideration in all cases where the scientific side of the problem has not got more special requirements. The test pieces, of which one half are lowered below the surface, give the advantage of showing the influence of corrosion when air and solution meet, where quite different corrosion conditions can be found. The method involves the disadvantage that a comparatively large number of test pieces must be examined to give

a reliable average figure, as the influence of corrosion is not evenly distributed over the surface of each test piece.

The chief object of these preliminary investigations has been to lay down the main corrosion process, and in this respect they have given quite satisfactory results. It has also been of importance to draw attention to the fact that from the practical engineer's point of view there is very little help derived from the type of corrosion investigations which have been made previously, consisting of a determination of the loss of weight per square unit, etc. It is therefore very satisfactory that the influence of corrosion on the strength properties is now being studied on a large scale by the Bureau of Standards in the United States, the D.V.L. in Germany, and others.

A method which is more suitable for many technical scientific purposes has been in use in further experiments, carried out in 1925-27 by Mr. Norlin and Mr. Larsson, civil engineers, under direction of Dr. I. Malmer, docent at the

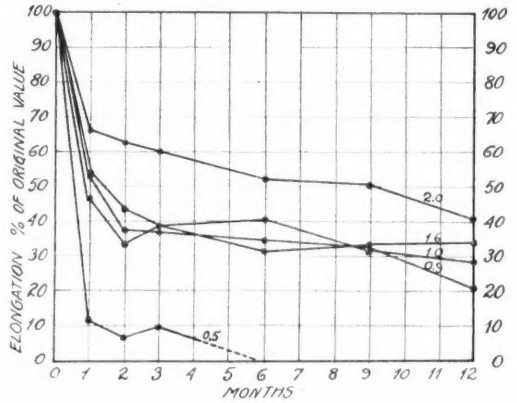


FIG. 5C.

Influence on unprotected duralumin with different thicknesses.

Royal Technical University in Stockholm. They used an apparatus, shown in Fig. 5A, by means of which the test pieces were alternately lowered into the salt solution during a certain period and afterwards lifted up and kept in the air during a period of the same length. This period has been four hours. The results arrived at (Figs. 5B, 5C) with this method chiefly agree with those from the method previously used, although according to Fig. 6 the corrosion process for duralumin seems to be somewhat different. The difference obtained is extremely interesting and is evidently caused by the deposit of corrosion products at the alternating dipping and lifting, which deposit after a certain time acts as a protection against further corrosion.

In order to facilitate the comparison between different dimensions of and material in the test strips, when studying the results of the investigations, the writer has in the different special cases introduced a factor which may be called the *equivalent of corrosion*. This equivalent of corrosion indicates the thickness of the outer layer of the test piece which has to be removed in order to get the same reduction of the strength of the material as through the influence of the corrosion in each special case. Fig. 7 shows the equivalent for duralumin and steel according to the writer's investigations in 1923. Figs. 8A and 8B show the equivalent of corrosion according to Norlin's and Larsson's investigations and calculated in the same manner. It may be noticed that the equivalent of

corrosion for duralumin varies with different thicknesses of the sheets, but differently for different makes. This seems to be fairly natural and would be caused by different methods used in the manufacture. With regard to steel, the equivalent of corrosion does not seem to be dependent on the thickness of the sheets.

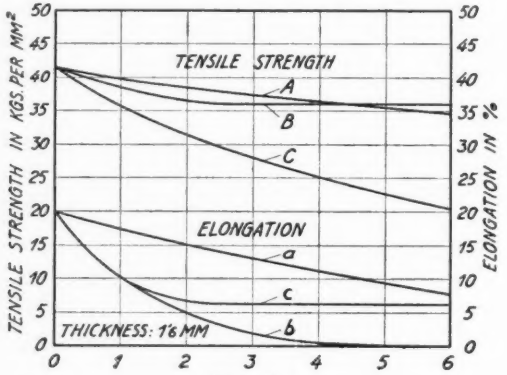


FIG. 6.

A, a and C, c belong to the investigations of Angstrom, B, b to those of Norlin and Larrson.

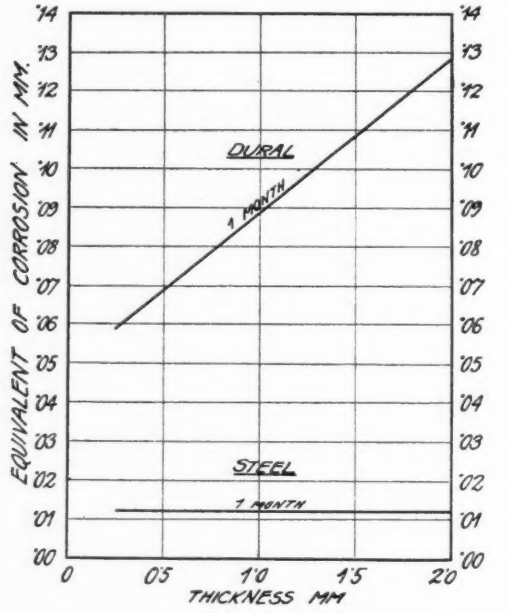


FIG. 7.

As the corrosion has to be considered as a superficial phenomenon it is evident that the percentage influence thereof on the strength of the material increases in proportion as the thickness of the material decreases. It may

therefore, from purely theoretical reasons, be supposed that among material with the same equivalent of corrosion the one with the lowest specific gravity ought to be preferred. *A priori* it seems, however, most suitable not to enter upon comparisons of this kind as practice may alter the conditions owing to the

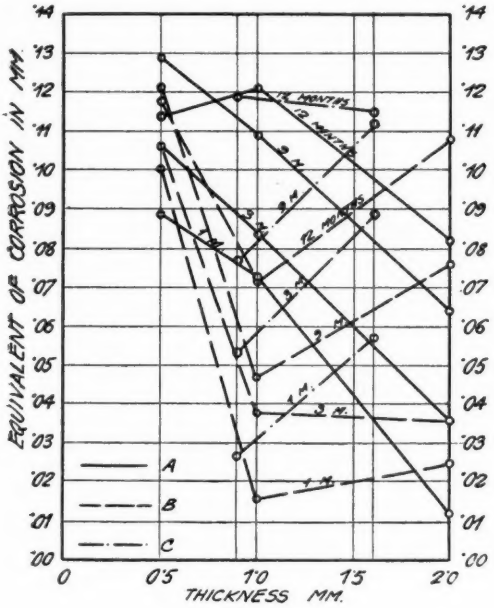


FIG. 8A.

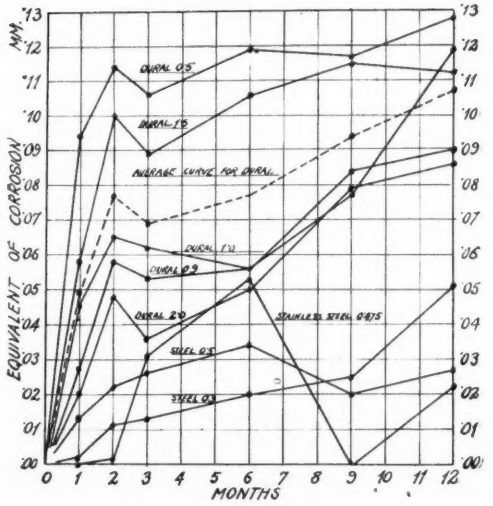


FIG. 8B.

engineer's solution of the design problems. It seems therefore more suitable to let the designer in each case, guided by the *equivalent of corrosion*, choose the most suitable material.

The corrosion investigations in question have also included an investigation into the efficiency of some means of protection. The results in that respect are shown in Figs. 9A and 9B. It is of great interest to be able to state

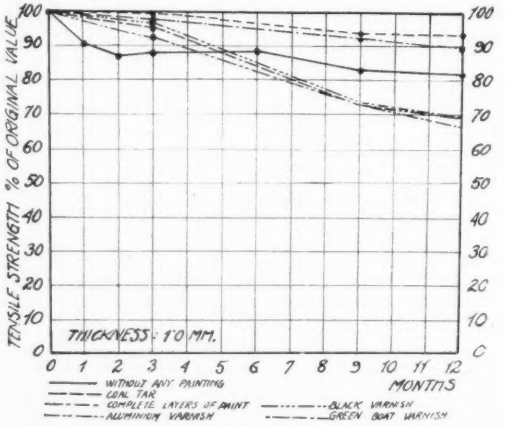


FIG. 9A.

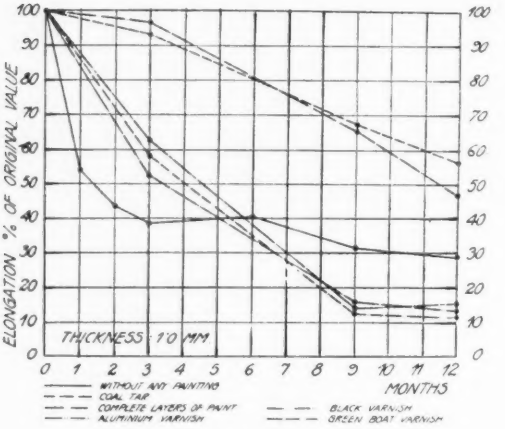


FIG. 9B.

that some of the means of protection after a certain time involve evident deterioration as compared with the unprotected material.

The equivalent of corrosion mentioned above, however, does not alone determine the influence of corrosion on the strength properties. The influence on the elasticity of the material is in certain cases most considerable (this applies in general to light alloys of the duralumin type) and must in many cases be considered as of great importance. This influence is specially noticed with

regard to fatigue stresses and these must be considered to a greater extent. The attached figures (10, 11, 12) show characteristic appearances of corrosion of duralumin, steel and "stainless" steel, which materials have been subject to

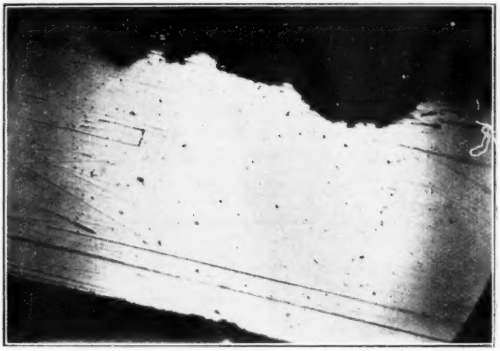


FIG. 10.

FIG. 11.

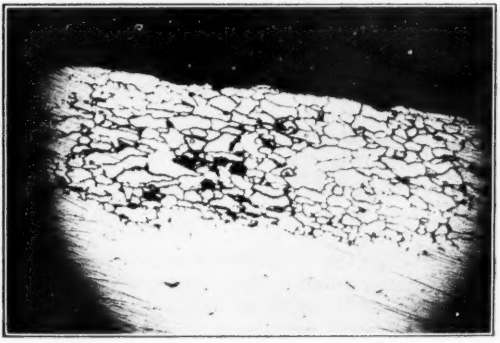


FIG. 12.

identical treatment. Knowing that the stresses in a scratch are increased in proportion to a factor $d\sqrt{(d/r)}$, where d = the depth of the scratch and r = the radius in the bottom of the scratch, one can immediately draw the conclusion from these photographs that the influence of corrosion on the fatigue limit must show considerable differences.

The Aeronautical Committee has made the question of the influence of corrosion on the fatigue limit subject to a systematic study. A special fatigue testing machine has been designed for the purpose. By making use of a simple method, indicated by the Government Testing Institute, this machine is capable of giving constant stresses over a certain part of the test piece. Readings of the moment can be taken constantly. Fig. 13 shows the appearance of

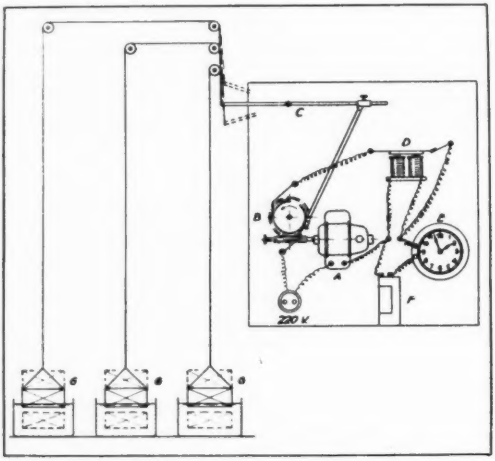


FIG. 13.

the machine. At present duralumin and a certain number of different kinds of steel are being tested. The corrosion is obtained through alternative dipping every 15 minutes, chiefly in accordance with the method previously used, which also seems to be used by the Bureau of Standards nowadays. The salt solution is of the same composition as the one used by the Bureau of Standards. It is desirable that investigations into the corrosion phenomena are carried out as much as possible in a way giving comparisons between the results from the research work in different places. It is of importance that the method gives quick results, but at the same time the corrosion process must not in any way show principal differences when compared with circumstances met with in practice.

Steel Construction

The Aeronautical Committee has considered it of special importance to develop sound steel construction both from a general technical point of view and with regard to the Swedish supply of raw material.

This task has been allotted to Professor Weibull at the Technical University in Stockholm, who has carried out preliminary theoretical work and technical tests. In the present state no exhaustive reports can be given on this work.

Engine Tests

The engine problem which the Aeronautical Committee has considered of greatest importance to study, in view of the climatic conditions in Sweden, has been the starting of aero engines at low temperatures. Under the direction of Professor Hubendick this work is being carried out by Docent E. Norlin and Mr. E. Björnsjö and N. Söderberg, civil engineers. An extensive study of fuels

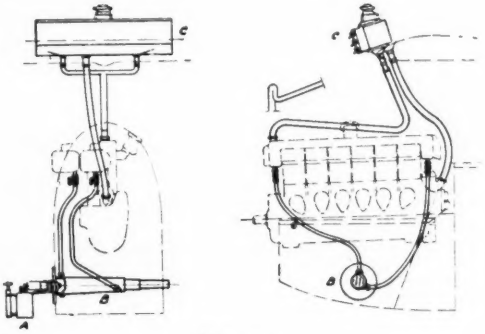


FIG. 14.

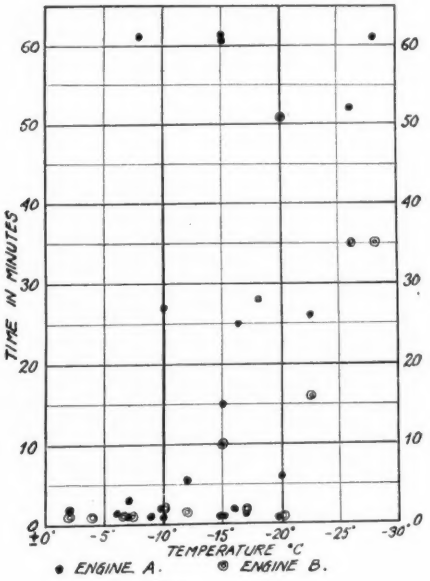


FIG. 15.

and oils has been carried out with the results that there does not seem to be any possibility of dispensing with warming up the engine before starting at very low temperatures.

The possibilities of warming up an aero engine are fundamentally different on water-cooled and air-cooled engines.

On water-cooled engines Dr. Malmer has introduced a device for warming up which has proved efficient in practical use. With this device the cooling water and thus also the engine are warmed up by means of a blowlamp. Fig. 14 shows the principle of the device.

On air-cooled engines, however, the problem is not so simple. Fig. 15 shows the results of some starting tests which have been carried out at different temperatures with two air-cooled engines of about 400 h.p. The diagram shows the time taken to start the engine at different temperatures. It is evident from the diagram that the difficulties in starting such engines are considerable at temperatures below $-15°$ to $-20°$C. At lower temperatures the oil grows so

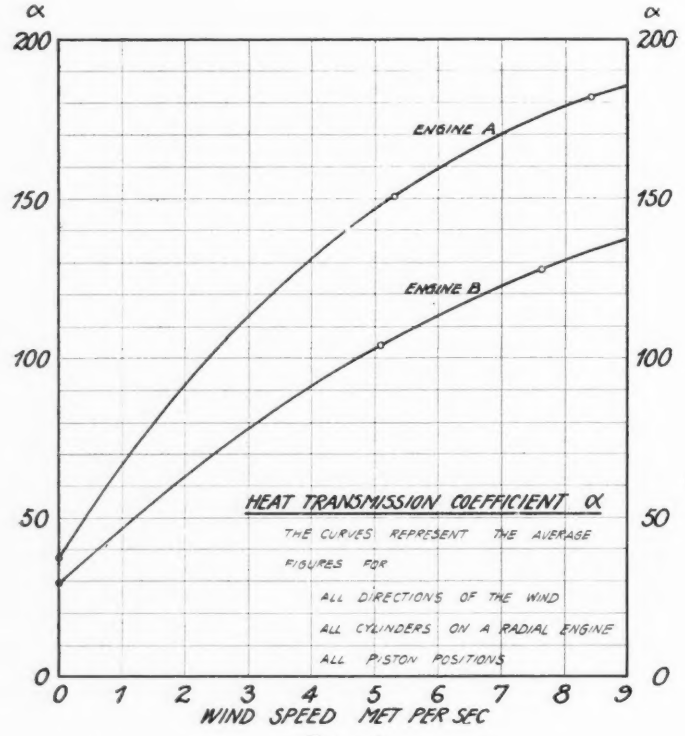


FIG. 16.

α is expressed as kg. cal. s sq. metre, hr. and °C., and is based on the inner surface of the cylinder.

thick and the carburation of the fuel so poor that the usual methods of starting the engine are not reliable. The only possible method seems to be the designing of a practical system for the warming up of the whole engine. As a link in this work the coefficient for the transmission of heat has been determined for the cylinders belonging to two types of air-cooled engines, both in a calm and at wind speeds below 8 metres per sec. The results of this investigation are shown in Fig. 16. With these results the quantity of heat can be determined which has to be conveyed to the engine under different circumstances in order

to maintain a certain difference in temperature between the engine and the surrounding air.

Based on the results the investigations now aim at finding the most suitable device for the heating of the engine. Two different systems will be tried.

Floats

With regard to floats there are essentially two problems to which the Committee has paid considerable attention, viz., the problem of obtaining a float construction making the take-off and landing possible on water as well as on snow and ice, and the possibilities of obtaining greater manœuvrability on the water.

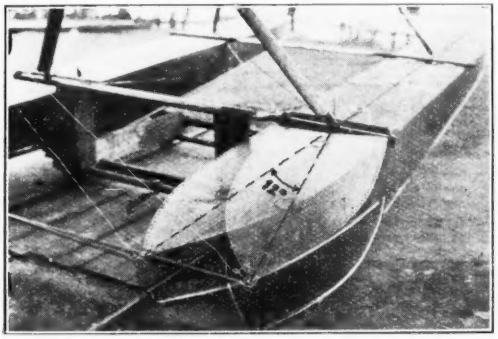


FIG. 17.

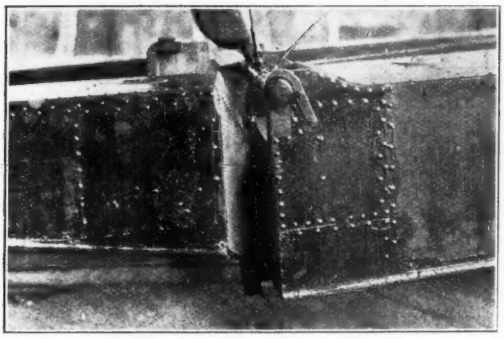


FIG. 18.

With regard to the first question, while it is true that surprisingly good results have been achieved by using ordinary floats when landing on snow and ice, it can hardly be said that this solution can be considered anything but a mere temporary arrangement. Although the wear when using ordinary construction is not abnormal, ordinary floats do not satisfy the demands of economy which are necessary for civil flying.

With regard to most floats it is not sufficient to give these an elastic mounting, but it is also necessary to make the bottom surface elastic. Preliminary tests in this direction have been carried out and there are hopes of

finding an acceptabie solution of this problem, one extremely important for northern countries.

The demand for better manœuvrability on water should be a fairly general one, but it has proved especially strong when landing is continually being made in rivers and the narrow waters of northern Sweden. The manœuvrability, *i.e.*, the aircraft's adaptability for turning in an horizontal plane on the surface of the water is, however, a problem which does not appear to have been very fully studied. In this respect Spaak has entered upon a series of investigations and tests which should draw attention to a field of research which seems to have been neglected.

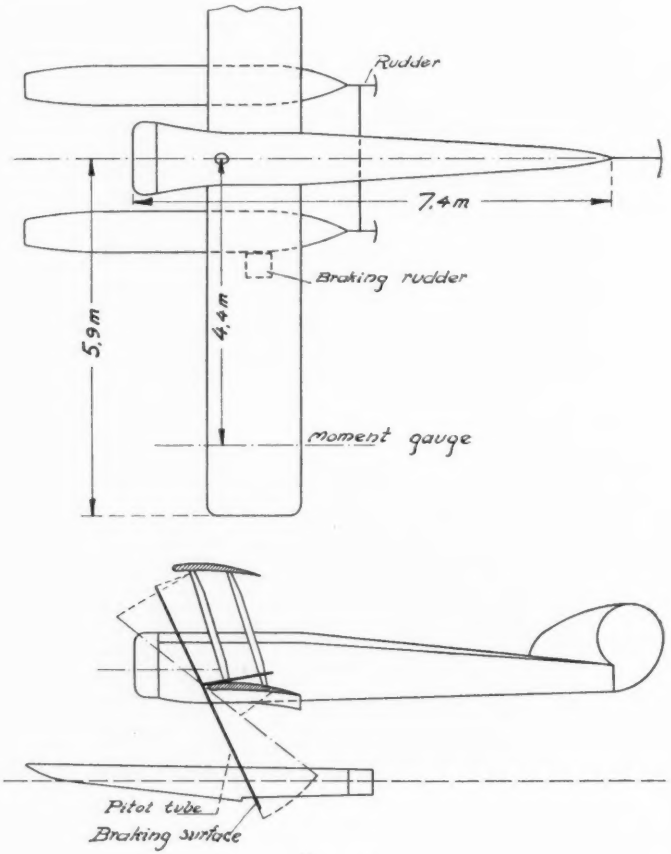


FIG. 19.

In his investigations Spaak has made use of an Avro aeroplane 504K of standard type, fitted with floats. As is shown in Fig. 19, the aeroplane has been fitted with a " moment gauge " consisting of a lever in one end, carrying a braking surface lowered into the water. Readings can be taken of the braking force, and thus the turning moment, acting on the aeroplane, can be determined too. Then with a certain constant turning moment the time taken to complete

a turn of 360° is measured. Fig. 20 shows the results arrived at in this way in calm weather and with an aeroplane speed of 63/4 knots. Spaak has carried out such comparative tests for the following different types of rudder: Air rudder, water rudder, braking rudder (in the water), and with the rear end of the float

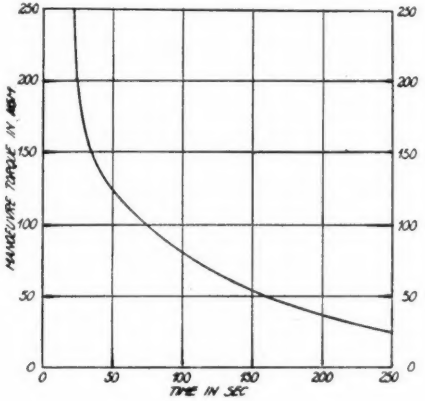


FIG. 20.

flexibly attached (Fig. 18). The last mentioned device has proved very effective. In this manner the turning moment obtained with different types of rudders can be directly determined.

Full-scale tests have been undertaken by the writer. Their object has been to show the possibility of using hydrofoils (Fig. 21) as additional items on a

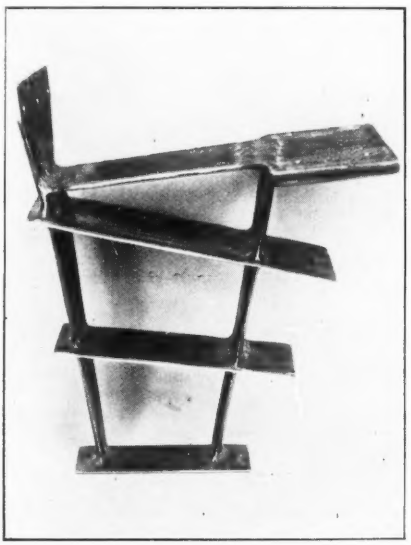


FIG. 21.

flying boat of the type shown in Fig. 22. Theoretically the use of hydrofoils offers definite advantages, among which the appreciable decrease in and concentration of stresses from sea disturbances are not the least. In this way it should be possible to reduce the empty weight of the flying boat and keep its seaworthiness. The comparatively limited tests which have been carried out with the above mentioned system have shown certain hydrodynamic advantages. A serious objection to it seems to be, however, that objects, floating on the water, of which in northern countries ice must be especially considered, can cause damage on the hydrofoils at the very high speeds which are obtained in this case. It should not be considered that this disadvantage cannot be eliminated, making it possible to let the distinguished contributions in this field, among others by Crocco, Ricaldini, Foralini, Cederblom and Guidoni, bear fruit.

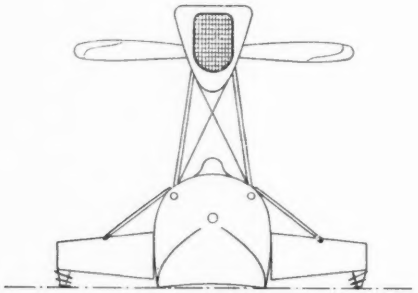


FIG. 22.

Skis

As regards skis, the Aeronautical Committee has made preparations for investigations as to the most suitable material, taking into consideration the desirability of bringing down the friction resistance to the smallest possible under all circumstances, *i.e.*, even when thawing. It is also intended to carry out investigations with regard to the most suitable dimensions of the skis under the widely different snow conditions. The constructional side of skis is also made subject to special investigation.

I have here, in a few words, given an account of the programme for the aeronautical research work of the Swedish Aeronautical Committee and it has also been possible to touch upon the results obtained.

Already in the last decade of the 19th century Sweden has had prominent and far-seeing scientists on the aeronautical field, especially Gustaf de Laval and Cederblom. To keep the spirit of research which inspired these men still alive and to try to direct it towards modern problems in aviation has been the endeavour of the Aeronautical Committee.

RECENT PROGRESS OF AERONAUTICAL SCIENCE IN FRANCE

BY

MONS. P. FRANCK

(A Paper read before the Society on July 22nd, 1929, at Olympia.)

I greatly appreciated the invitation of your Society to give this lecture on recent progress of aeronautical science in France; and if I hesitated a moment to accept it was only because I feared the difficulty of the task.

As a matter of fact, aeronautical science covers such a wide field that it is difficult to give an exact idea of the progress made in the different branches. Many results are obtained by the improvement of various details, and it is not easy to see clearly the influence of every one of them. I shall endeavour to be as clear as possible, and to describe to you the main purposes of the French engineers and the results they have obtained in the way of their realisation.

The main objectives of French aeronautical progress have been safety in flight, development of commercial aviation, and metal construction. In every part of aeronautical science we shall find progress along those lines. They

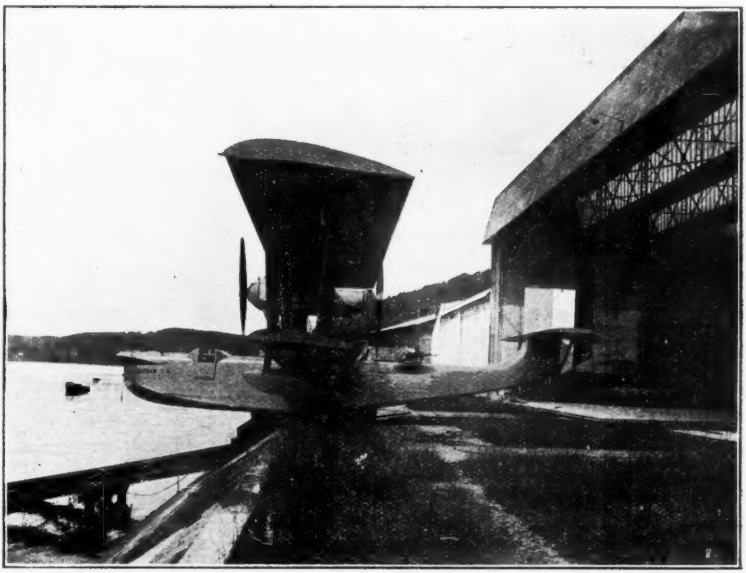


FIG. 1.
Latham 47, Renault.

concern aerodynamics, building of aircraft, flying boats, motors and aerial navigation.

I. Aerodynamics

M. A. Lapresle delivered a lecture on the subject of French wind tunnel methods before your Society on April 11th last. He described the result obtained of French researches concerning aerodynamical stability, and gave the conclusion of an experimental investigation of the velocity field round a wing profile. I do not intend to discuss those questions, and I advise those who did not hear that lecture to read the paper that has been published on that subject

Fig. 2.
Hydravion, Type 17 à 4 places de tourisme. Schreck F.B.A.

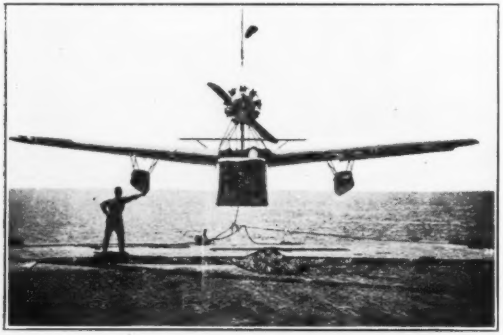


Fig. 3.
Hydravion Le O.H. 180.

by your Society. They will see how the conditions of pitching stability and directional stability have been obtained with small models. They will find a certain number of curves obtained with different fixed tail surfaces and also with different settings of the tail plane with respect to the line of flight.

M. Lapresle shows also the modifications of the curves of moments for different settings of the elevator. Interesting results are given in the same way for directional stability. These studies have been very useful in developing the security for different aircraft in certain cases of flying which might be dangerous.

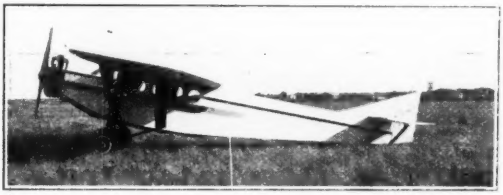


FIG. 4.

The Farman 190.

Full scale experiments showed that certain acrobatic aircraft seemed to be dangerous under certain conditions. The wind tunnel found the causes and indicated the modifications to be made. Those modifications were quite efficient.

In the second part of his lecture, M. Lapresle describes the experiments concerning the velocity field around a wing profile and gives the results. These

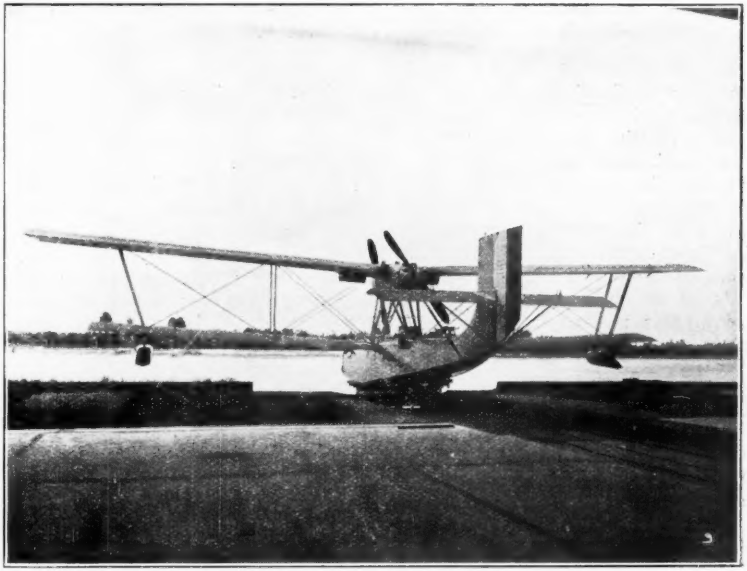


FIG. 5.

Latham 47, *Renault.*

may be used for choosing the suitable place to mount speed indicators or small propellers driving electrical generators. The distribution of pressure in the field of the aerofoil thus gives interesting results.

II. Aircraft

We have stated that the main objectives of French aviation have been :—

(1) Safety;
(2) The development of commercial aviation;
(3) Metal construction.

Fig. 6.
Hydravion Le O.H. 198.

In order to develop safety many precautions have been taken against fire; the strength of construction has been carefully supervised; the ability of a plane to fly with one engine stopped has been improved; special brakes have been installed, automatic stabilisers have been tested.

The development of commercial aviation requires that aircraft should not only give good performance, but should also be so constructed and of such material that they will last and can be easily repaired

While designers were improving their planes and engines, the testing department of Service Technique realised the need of a better adaptation of the methods of measuring performance. Interesting progress has been made in France in this respect, and we shall examine the details of this progress in order.

Fire

To guard against fire, one must avoid every cause of it. In spite of that care fire may occur. The pilot must have warning and possess means to extinguish the fire. All aircraft are required to be equipped with fire-proof bulkheads between the engine and the fuel tank. One special valve may be closed by the pilot to cut off the supply of petrol from the engine. Special anti-backfire carburettors are being manufactured. The air intake pipes are placed outside the engine cowling. Every detail of the installation is studied in order to avoid the possibility of fire.

In case, however, fire should occur, the pilot is warned by a special alarm and can fight the fire with powerful extinguishers.

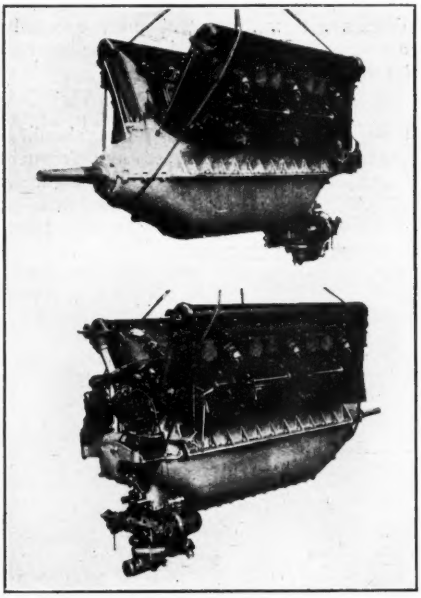


FIG. 7.
Moteur Hispano 650 C.V.

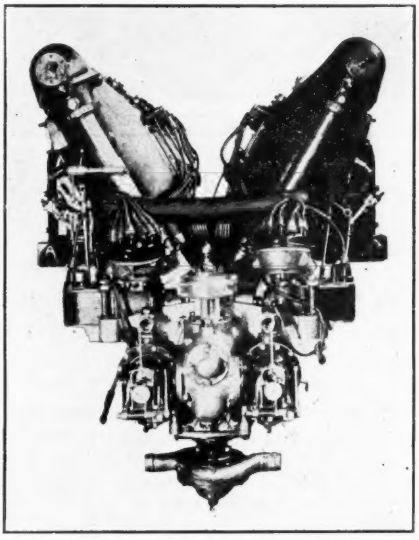


FIG. 8.
Moteur Hispano 12L. 600 h.p. à 2000 t/u 140/170.
The cylinders are mounted into two water tanks.

Some of those details are well known, and, carefully carried out during the last two or three years, have produced remarkable results. The casualties by fire are now fortunately very rare.

Load Factor

Another element of security is that a plane should be constructed in a strong and solid manner. This is calculated and frequently proved by static tests. In every case one must multiply the different forces by the load factor. The C.I.N.A. regulations give the number 5 for this coefficient. That rule is strictly applied in France, and many French aircraft have a higher load factor than 5. The forces depend upon the case. The C.I.N.A. regulations ask for three well known cases. With certain new wing profiles of acrobatic aircraft we think that it is not sufficient, and we intend to verify the forces on and strengths of certain parts in other cases of flying. The question is now in consideration.

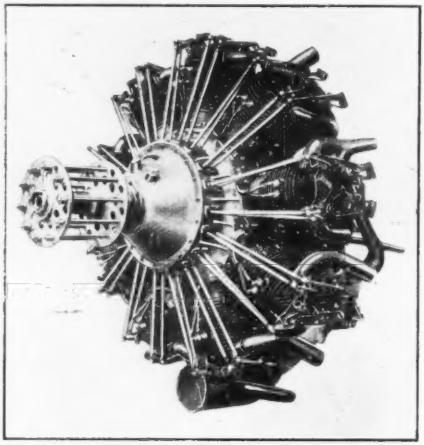


FIG. 9.
Salmson 18 A.B., 500 C.V., 18 cylinders.

The construction of all aircraft described has been calculated and tested as mentioned above. We therefore think that we obtain a very large margin of safety in regard to the strength of construction.

We hope that the experiments we are now conducting will furnish us with sufficient data to allow us to do away with the static tests, except in particular cases.

Multi-Engines

The third element of safety is to avoid forced landing. The best way to do that is to have reliable engines. An engine, however, has not yet been constructed of which it is possible to say that it will never have any trouble. For that reason we think that it is necessary to have multi-engined aircraft which are able to fly to the next landing field with one engine stopped.

Aircraft exist which have shown such performances. In July, 1928, Lieut. de Vaisseau Paris flew two hours about the Azores with one of his engines stopped. Generally speaking, the propeller of the engine that has been stopped is turned by the air and causes a great head resistance. With twin engines mounted laterally it increases the rotating torque. The resistance of the pro-

peller is very important. Experiments have been made with a Farman 180, and it was found that the propeller was turned by the air at a speed of 800 revolutions per minute. That represents an important amount of power absorbed by the rotation of the engine.

Two solutions of the question have been proposed :—

(1) To lock the propeller so that it cannot turn ; or

(2) To fit it with freewheel mechanism.

Calculations show that the second method is better than the first. Experiments are being made to verify these results. They are not finished, however, and we cannot give exact results.

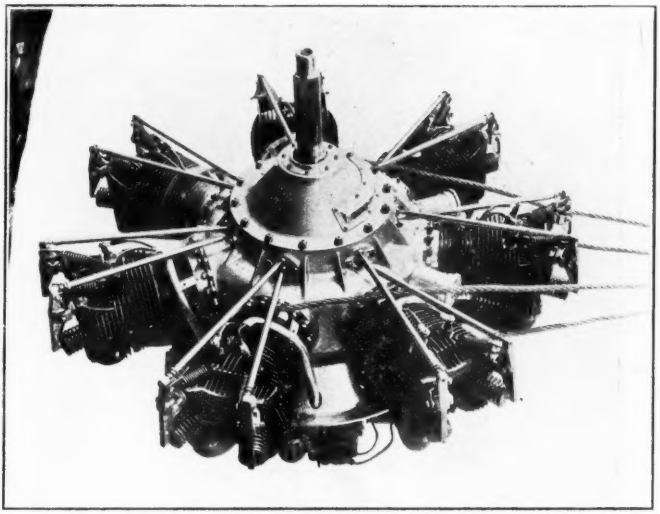


FIG. 10.
240 *C.V. Lorraine.*

Flying with one engine stopped on a twin-engined aeroplane is also a difficulty when the airstream of the two propellers does not produce symmetrical pressures on the tail planes, and when their torques are also not symmetrical.

In order to avoid that case, twin-engined aeroplanes have been fitted with engines rotating in the opposite direction. The experiments have shown an improvement, but the results are still to be confirmed. Tests are also being made to change the direction of the axes of the engine and their positions, and so determine the best conditions of flying with one engine stopped. Those experiments have not been completed.

Brakes

While the purpose of the multi-engined aeroplanes is to avoid forced landings, we must take precautions in case they should occur.

It adds to safety to have brakes, and they are already used in several countries. But, generally speaking, ordinary brakes are used, which, if the plane is equipped with certain type of landing gears, might cause it to turn over. The constructors who use them are obliged to have a great "angle of garde" which depends upon the position at which the landing gear is mounted in relation with the centre of gravity. The conditions for taking off depend upon this angle, and they are not always of the best. French designers have

overcome this difficulty by special arrangements which provide that the brakes go out of action if the tailplane rises. By that means, they may adopt in every case the best "angle of garde." Several sets have been manufactured with this end in view. Those of M. Messier, of M. Dhainaut-Fauvelere, and of the firm Breguet have been described in the "Revue Générale de l'Aéronautique" (tome 9) by M. Suffrin-Hebert. They have been tested, and the results are excellent. They will soon be mounted on many planes.

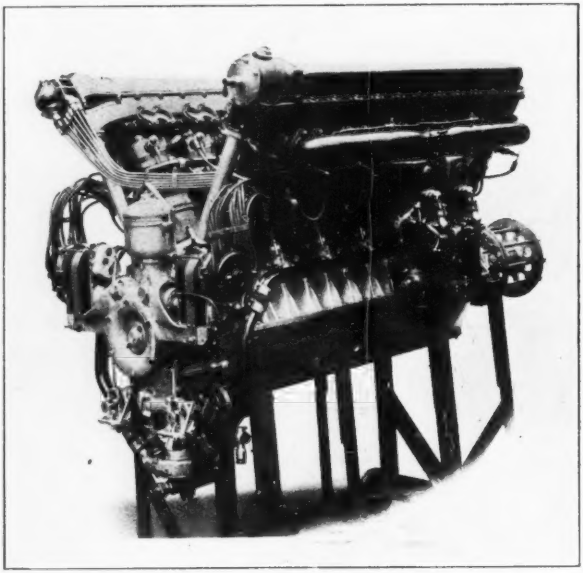


FIG. 11.

Renault 490 h.p. gives 500 C.V. at 2,100 revolutions p.m.

Stabilisers

All these safety precautions and appliances of which we have spoken are to be put in immediate service. One must, however, look to the future, and prepare for safety of air traffic when long distances must be made without landing. That is the purpose of the automatic stabilisation of aircraft. Automatic stabilisers will lessen the fatigue of the pilot, allow him to give all his attention to piloting his aeroplane, and to have a smaller crew. Many investigations have been made in France as well as in the other countries. As a result of the experience we have gained we are now able to judge what types of stabilisers to use under various conditions. Generally speaking, we know that an incidence indicator is the best instrument of direct control of the elevator; a pendulum, aerodynamically operated by the movement of the aeroplane is the best for the operation of the ailerons, and a gyroscope or a repeating compass is the best for the rudder. An ordinary aircraft has been fitted with the incidence indicator and the pendulum; it made several long flights. I had myself the opportunity to make some, and the experiment proved that it is really practical and it is possible to relieve the pilot altogether by mechanical controllers during flying. One pilot is always necessary, but he has only to take-off, to land, and take the controls if the mechanism breaks.

Metal Construction

The question of economy is one of the most important for commercial aviation. For that reason commercial aircraft in France have metal construction and, generally speaking, the tendency in the future will be to have only this kind of construction. We are also beginning to use steel as well as duralumin. The covering of the plane is not usually metallic. We have not as yet decided whether a fabric covering is cheaper and preferable to a metallic one.

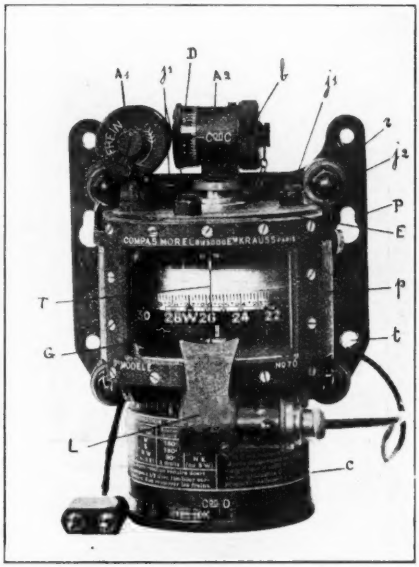


FIG. 12.
Compas Morel with vertical scale.

Plywood appears to be very advantageous but is somewhat heavy. We consider that a covering of duralumin or plywood should be generally used only if it forms an integral part of the structure.

Performances

Before describing to you the most recent types, I must say something about the method of measuring their performances. The speed is measured carefully over a known course. Formerly the aeroplane was equipped with one propeller adapted for the rated r.p.m. at full throttle. But those conditions are entirely different from the conditions of practice. For that reason, the designer is now free to fit the aircraft with a propeller adapted for a lower power than that given at full throttle, provided that he does not exceed the rated r.p.m. Under these conditions the results, and particularly the speed, are much nearer the real performances that are obtained in actual commercial operations.

On the other hand, the French Service Technique de l'Aéronautique employs a new method for the calculation of the horizontal speed at different altitudes and for different revolutions of the engine. That calculation may be done after measuring the speed over the given distance and the revolution at full throttle at different altitudes. The method, based on the conditions of the flight with

constant torque, has been described in the "Instruction sur le calcul des performances," published by the Service Technique de l'Aéronautique. It is interesting, because it gives the speed in every case, after very precise measurement, the measure of the speed near the ground, over a fixed distance, and the measurement of the revolutions. One eliminates entirely the mistakes due to the speed indicators.

The performances of French aircraft have been very much improved. It would take too long to speak of the French aircraft actually in service; they are

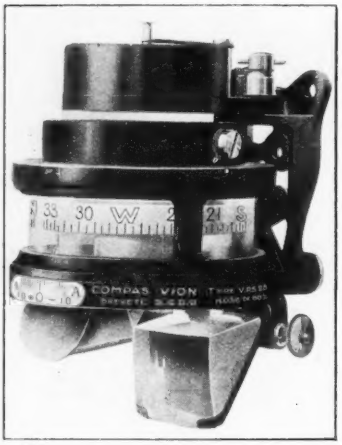


FIG. 13.
Compas Vion with vertical scale.

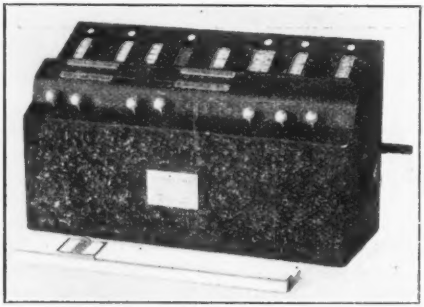


FIG. 14.
The reckonings calculator of Capitaine de Vaisseau Le Sort.

well known. I have not time to give the performances of all the new French commercial aircraft. You will find, however, the performances of three of them in a table appended. They are the Latecoere 281, Farman 190 and Bernard 192.

The Latecoere 281 is a new type, the performances of which are quite good for a commercial plane. The success of the designer has been obtained after a long series of trials and modifications. Every detail has been carefully studied. The profile of the wing has been progressively modified, the position and the

AIRCRAFTS.	ENGINE.	P	P_f	P_e	$P_p \div P_e$	VM	$Z\,60'$	L_D	L_A
Latecoere 281	Hispano 500 c.v.	4040	de l'ordre **900** sera précisé ult[t]	de l'ordre **450** sera précisé ult[t]	**1350**	240	5200	250[1]	245[2]
Farman 190	Gn. Rh. Titan 230 c.v.	1688	447	273	**720**	185	4100	180	250[2]
Bernard 192	Gn. Rh. Jupiter 420 c.v.	3200	839	377	**1216**	205	3800	**300**[1]	205[2]

P = total weight.
P_f = freight load.
P_e = fuel load.
VM = maximum speed.
$Z60'$ = the ceiling after 60m. flying.
L_D = distance of taking off.
L_A = distance of landing.

[1] Will be easily improved with one better "angle de garde."
[2] Will be improved with brakes.

RANGE.—Approximative calculations with the P_e indicated in the table.

Lat. 281 = 850 à 900 km.
F. 190 = 850 à 900 km.
B. 192 = 750 km.

shape of all the exterior parts of the landing gear and of the engine have been methodically improved. The structure, the equipment, the arrangement of the cabin, have been studied with the same care.

The Farman 190 is the type of plane used by Bailly and Reginensi during their flight from Paris to Saigon and return. Their load never exceeded the load of the navigation certificate. When they increased their flight radius, they took a greater supply of fuel and diminished proportionally the load of their machine in other respects. In reality this was a commercial trip, the regularity of which was excellent. It was not a long distance flight.

The Bernard 192, which is a commercial aircraft, is similar to the plane used by Lefevre, Assolant and Lotti in their recent trans-Atlantic flight. Only the engine was different and the success of this flight is the best proof of the qualities of this machine.

III. Flying Boats

Floats

Commercial aviation generally prefers flying boats to land planes equipped with pontoons. The reason is, perhaps, that our commercial lines use their machines over sea and not over lakes or rivers. Nevertheless, some aircraft have been fitted with pontoons, and the pontoons have been designed in the same way as in the other countries.

Hulls

For flying boats, the hulls are generally broad. French engineers seem to prefer that method of construction, as the flying boat rises from the water more quickly, and it is thus possible to take off inside a harbour or a bay having calm water.

It seems that this method gives very good results. We cannot examine here all the recent French flying boats. We shall only speak of one, the performances of which are particularly interesting. It is the C.A.M.S. 54.

During the trials made for the preparation of a long distance flight, the C.A.M.S. 54 succeeded in taking off with a total load of 9,600 kgs. As it is fitted with two engines of 600 h.p. each, it lifted exactly 8 kg. per horse-power. That is a very interesting performance.

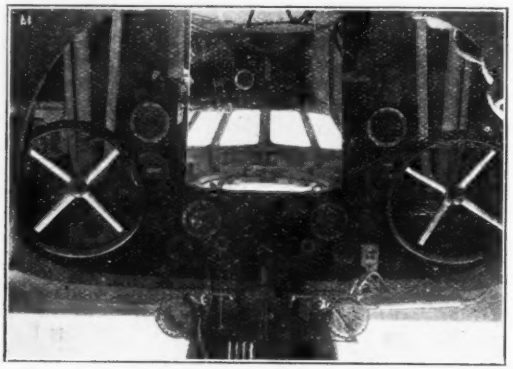


Fig. 15.

Latham 47, Renault.

Cockpit instruments, with a view in the place of the radio and navigator.

The same flying boat succeeded in beating the record of altitude with a load of 2,000 kg.

A similar seaplane with very few modifications (C.A.M.S. 53) is on service on two commercial lines which are particularly difficult—Marseille-Alger and Dakar-Iles Du Cap Vert. They have given every satisfaction.

From the same point of view the Liore Olivier 198 is to be mentioned. It has been in service several years on the line Marseille-Tunis, and has kept up a perfectly regular service. Its seaworthy qualities were proved in 1928, when it was forced to come down during a terrible storm. It floated three days, and was then recovered in good condition.

FIG. 16.
Latham 47, Renault.
Cabine Radio.

Amphibians

The French designers of flying boats also build tourist planes. The amphibians Liore 180 and the Schreck types are specially adapted for this use. They have been described in many publications, and I hardly think it necessary to mention their performances here.

Metal Construction

Some metal flying boats have been constructed in France. They have been tried with success, but no definite type of metal flying boat is yet in service. Investigations are being actively made, and we have begun the construction of metal flying boats of 18 to 20 tons.

IV. ENGINES

The French manufacturers of engines have specially studied the question of weight, consumption of fuel, and durability. The appended tables give the performances of the most characteristic engines recently manufactured.

Lightness

The decrease in weight has been obtained by increasing the speed and using reduction gears. By this means Renault, who obtained the excellent weight of 0.850 kg. per h.p. with his 12 j.A., improved that result by increasing the number of revolutions p.m. from 1,800 to 2,100 r.p.m. The nominal power has been increased from 450 to 500 h.p., and the weight per h.p. has decreased from 0.850 to 0.770 kg. For the 12 k. the number of revolutions has been

increased from 1,800 to 2,050; as a result, the power has increased from 550 h.p. to 600 h.p., and the weight per h.p. has decreased to 0.800 kg. Hispano has the same result—0.790 kg. for the 600 h.p. and 0.800 kg. for the 650 h.p.

Fuel Consumption

The high speed gives a lower fuel consumption. This low fuel consumption is also obtained by a higher compression ratio. As we are limited in that way, progress has been made at altitude, by means of superchargers. The most important work on the subject is Farman's. The results have been published by "La Technique Aéronautique" of last February and March. The last engine of Farman is a 750 h.p. with 18 cylinders inverted. The speed is 2,600 revolutions p.m. It is very light, but the exact performance is still to be determined.

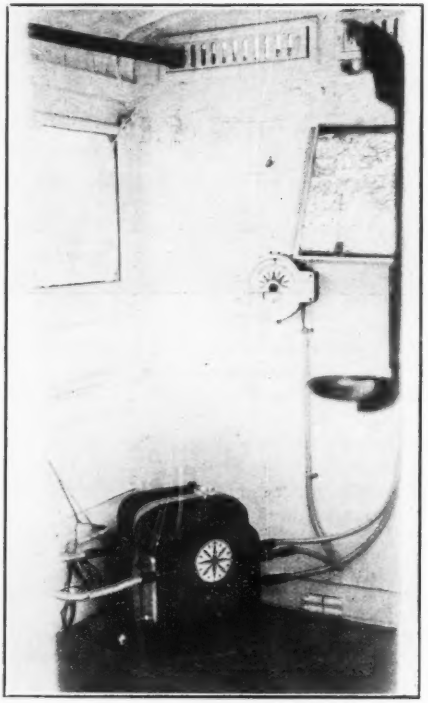


FIG. 17.
The Mengden.

The lubricating oil consumption has been particularly studied by Lorraine. In the engine 18 ka. (650 h.p.) that consumption is only 6 gr. per h.p. hour.

Durability

Durability is obtained by sound construction, and great care taken in every detail. Special measures have been taken in this way by Hispano in his 650 and his 500 h.p. 12 N.b., the cylinder of which has been treated by a specially treated process (nitruris).

Name of the manufacturer.	Type of engine.	Nominal power.	Nominal revolutions.	Cylinders.	Equivalent of strength.	Total weight.	Weight per h.p.	
Hispano	12 L 6	600 h.p.	2000	—	620 h.p.	475	0.790	Water-cooled
Hispano	12 N 6	650 h.p.	2000	—	750 h.p.	520	0.800	Water-cooled
Hispano	—	250 h.p.	2000	—	285 h.p.	274	0.916	Water-cooled
Lorraine	18 KD	650 h.p.	2000	18 W	690 h.p.	621	0.950	Water-cooled
Lorraine	5 PH	110 h.p.	1650	5 radial	124 h.p.	169.5	1.540	Air-cooled
Lorraine	7 M 6	240 h.p.	1800	7 radial	284 h.p.	258	1.180	Air-cooled
Lorraine	14 LA	470 h.p.	1800	14 radial	535 h.p.	450	0.950	Air-cooled
Renault	12 SA	450 h.p.	1800	12 V	470 h.p.	384	0.850	Water-cooled
Salmson	18 A 6	500 h.p.	1700	18 radial (double)	549 h.p.	460	0.920	Air-cooled
Salmson	9 AD	40 h.p.	2000	9 radial	46 h.p.	70	1.750	Air-cooled

These two engines have another interesting point in their construction. The heads of the cylinders are of light metal, and are screwed on the bodies. Water cooling is by direct contact of the cylinders in one water jacket (see Revue " l'Aeronautique ").

The well known 600 h.p. Hispano, which has not these interesting improvements, demonstrated its exceptional durability during the long distance flight of Costes and Le Brix and during the crossing of the Atlantic by Assolant and Lefevre, so that much may be expected of the two new engines.

Air-Cooled Engines

All the engines previously mentioned are water-cooled. French manufacturers are also constructing air-cooled engines. The most recent ones are those of Salmson and Lorraine. Salmson has a very progressive series from 12 h.p. and 3 cylinders to 500 h.p. and 18 cylinders. Lorraine has three different engines in service, and he has designed a complete series from the lowest powers to the highest (actually 470 h.p.).

Fuel

The research work of French aviation on this side is not confined to the manufacture of engines. Tests for finding suitable fuels have been actively carried on. A high temperature of ignition at free air has been found. Several trials have been made with Makhonine fuel and Ferrie fuel. Very good results have been obtained, but some improvements are still necessary. From this point of view it is interesting to note that Peugeot has constructed a new 240 h.p. engine which is specially made for the use of ordinary petrol or for the use of the new fuels. The tests on this new engine are not yet finished.

V. Navigation

Aerial navigation contributes to the safety and to the regularity of operations of commercial lines. In navigation, as in the construction, many details have been improved. We shall only discuss the most important advances which have been made.

Compass

The French industry has had for a long time very good compasses; the manufacturers have improved them by adopting a vertical scale and reducing the size in order to facilitate the installation in small cockpits. They have succeeded in making them practical and retaining all the good qualities of the old compasses.

Another interesting advance has been made by M. Mengden, who succeeded in making a very good selenium repeating compass, which has been experimented with for a long time and has proved very satisfactory.

With that compass and an anemometer, he has designed a route indicator, which gives remarkable results. This apparatus is described in a communication I made to the International Congress of Civil Aviation in Washington in December last.

Machine for Calculation of Reckonings

Considerable progress has also been made in the calculation of reckonings. Capitaine de Vaisseau Le Sort has designed for the Navy a new machine for the calculation of the reckonings. That machine has been adapted for aviation. Its weight is 7 kilos, and its dimensions are 135 by 195 by 350 (centimetres). It gives the angles with an accuracy of less than five minutes. It is simple to use.

Navigation by Night and through Fog

Important work has been done on navigation by night and through fog. Three different problems are presented—piloting the plane, navigation, and landing.

The question of piloting an aeroplane was solved some years ago by the *controleur de vol*, but it was not much used by pilots. The efforts made by the firm of Farman to teach blind flying have given very interesting results.

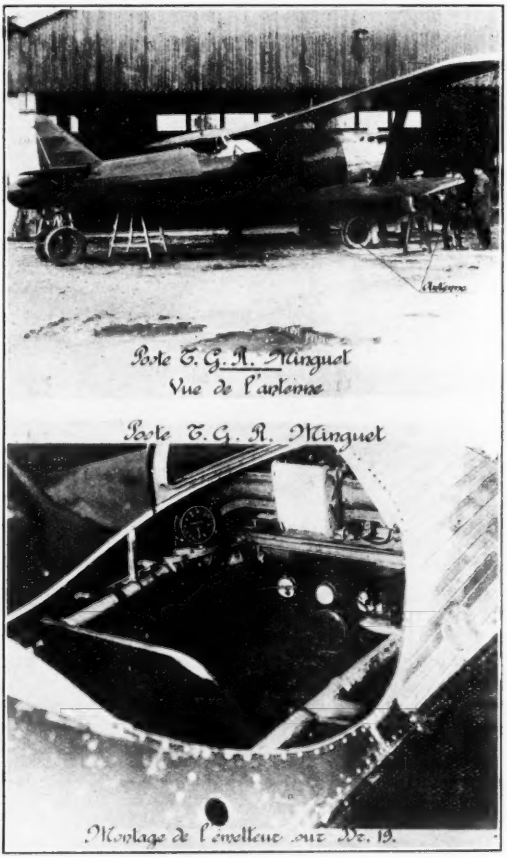


FIG. 18.

The installation of the Minguet radio set for the flight to Africa.

For navigation through fog two systems have been experimented with, direction finders mounted on the planes and radio-beacons. The first direction finders were made with the collaboration of the Service Technique de l'Aéronautique by the firm Radio L.L.

That directional wireless system proved to be very satisfactory during a long distance flight by Capitaine Cornillon. One type of direction finder is being produced on a large scale by Radio L.L., and other manufacturers are preparing

different types. One difficulty of their use is the necessity of shielding the circuits, magnetos and spark-plugs of the engines. French engineers have succeeded in avoiding that difficulty by connecting short resistances between the high tension binding post of the sparking plug and the magneto wires.

The most important research on radio-beacons has been made by M. Aircardi. The principle of his method was given in a communication delivered at the International Conference of Washington. The peculiarity of his radio-beacon is that it uses short waves. Static interference apparently causes great difficulties near the tropics when using long wave radio-beacons. These are reduced to a minimum by the use of short waves.

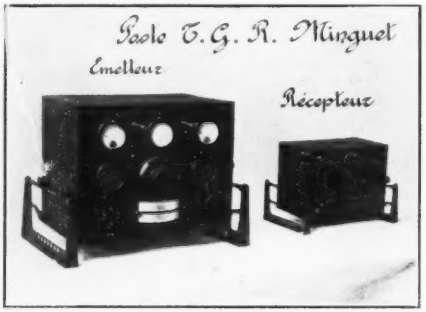


FIG. 19.
Minguet radio set.

Many communications are now made by short waves in the Sahara desert, and we intend to have short wave radio-beacons for commercial lines in that country. Objections have been made against short wave radio-beacons. It has been said that the beam may change its direction at certain times of the day. That has not happened during the many experiments which have been carried out, however.

The question of landing in fog is certainly a difficult one. It necessitates that the aircraft should arrive exactly over the aerodrome, and that the pilot must be able to know his height above the ground. All the experiments made in France show that the leader cable is the best means of directing the pilot exactly to the aerodrome. The method is quite useful, and the accuracy is of the order of 50 metres at an altitude of 500 metres. Lower, the accuracy is still better. The experiments are now finished, and a study is being made of how to put the cable into practical use.

The measurement of the height above the ground is not as successful. The " Comité de Propagande Aéronautique " organised a competition last year to find a solution. That competition was for designs only. Many were submitted, but only two or three were considered. They are now being constructed and have given certain practical results. There is still much research work to be done on the problem.

Radio Communications

In all circumstances regular airlines need good radio communications. The most interesting work concerns short waves, particularly in tropical countries. Short waves are also being used for long distance communication. Radio transmitting sets giving a range of the order of a thousand kilometres with long waves are much too heavy and require too powerful generators to be carried

on board an aeroplane. On the other hand, it is possible to transmit over long distances with short waves and low power.

Lieut. de Vaisseau Paris to Azores and Lieut. Marie and Lieut. Boulemer to Africa, both had a light set of 300 watts constructed by M. Monguet.

The set used by Lieut. de Vaisseau Paris has been received in France from the Azores. He was also heard after landing. That is a very practical result.

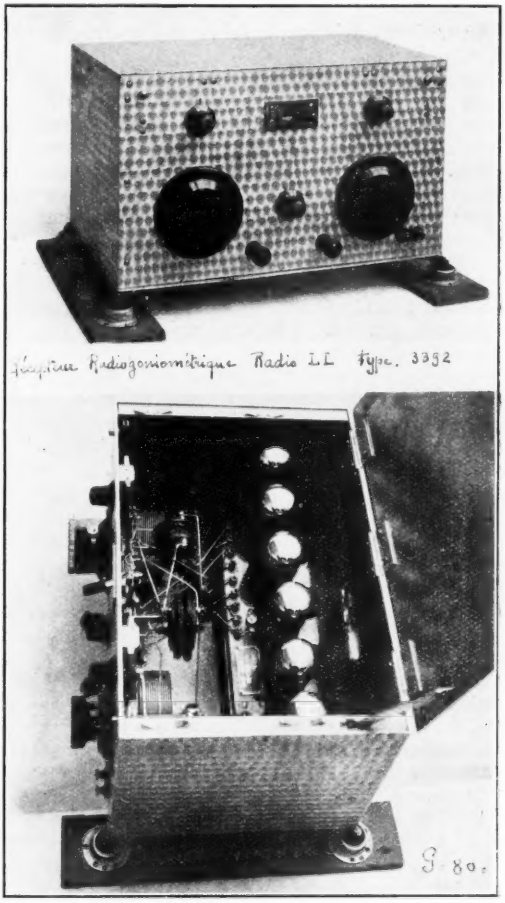


FIG. 20.

The same aerial has been used while flying and at sea, and it is very advantageous not to have to erect a special aerial after the machine comes down.

Lieut. Marie and Lieut. Boulemer were picked up in France during the whole of their flight, up to a maximum distance of 4,000 kilometres. (See "La Vie Aérienne," 31st December, 1928).

Some people fear that short waves give silent zones. That is certainly true for certain waves, but during those flights and also during many other

experiments, we have found short waves which gave no silent zone. In any case it is possible to use two different sets of waves, chosen in such a way that the one is received when the other is not. It does appear that short waves will be very useful for certain regular air lines.

VI. Results

At the beginning of the lecture it was said that the aims of French engineers in the last years were in the direction of greater safety and of helping the development of commercial aviation. It is interesting to consider to what extent they have succeeded.

The statistics of accidents for some years back give nearly the same number of accidents per annum. But a greater distance is flown every year, and it is reasonable to estimate that the increase in mileage is about 10 per cent. per annum. Therefore it is certain that the methods for increasing safety have improved every year.

Regarding commercial aviation, the regularity of the traffic on the line Marseille-Alger gives an idea of the progress of our flying boats and of our methods of aerial navigation. I do not think that there exists anywhere else in the world a regular line of the same length over sea. On the other hand, the "Compagnie Generale Aeropostale" has been able to fulfil his contract in spite of the great distances and of the difficulties of crossing over desert countries which have not yet been pacified. The efficiencies of the machines and engines have been a great factor in that success.

It is to be hoped that France will continue to play her important part in the development of aviation. The organisation of the new "Ministère de l'Air," the importance of the expenditure made this year for prototypes, and the number of additional investigations, demonstrate that next year will show in France a very important advance in the aeronautical science.

AERONAUTICAL PROGRESS IN GREAT BRITAIN

BY

THE DIRECTOR OF SCIENTIFIC RESEARCH, AIR MINISTRY

(H. E. WIMPERIS, ESQ., C.B.E., M.A., F.R.AE.S.)

(*A Paper read before the Society at Olympia, July 24th, 1929.*)

The application of scientific principles to the design of aircraft and aircraft equipment during the post-war years has yielded results which are becoming increasingly apparent. The time interval which elapses between the conception of an idea and its application to production aircraft is necessarily long, but it would seem that we are just commencing to reap the reward of much patient study.

An attempt will be made to present a picture of the progress which has recently been made and to indicate the lines along which further research would appear most profitable. In making this review it is inevitable that attention should be paid particularly to Service aircraft. The more difficult the problem the greater is the ingenuity required to solve it, and the ever increasing demands made upon the designers of Service aircraft have stimulated research to perhaps a greater extent than is the case with civil aircraft, the requirements for which are less complex.

The problem facing the designer of modern Service aircraft is not only to design an efficient aircraft as such, but also to provide that its crew can effectively perform the duties imposed upon it by the various operational requirements. The crew must be comfortable; the various instruments must be accessible and yet not impede necessary movement, and, above all, the view for each member must be correct for all the varied duties of fighting, navigation, bomb sighting, landing, flying in formation, etc. Many of these requirements are mutually antagonistic, and it often demands the utmost ingenuity to effect the best compromise. Moreover, ever increasing demands are made for aircraft of extremely high performance, sometimes at altitudes far above normal working heights of only a few years ago.

It can be said that British aircraft constructors have been able to keep pace with these demands. A comparison may not be out of place to show the high pitch to which aircraft design has now developed. Ten years ago the single-seater fighter was hardly more than an ordinary small aeroplane on which two machine guns had been mounted. To-day, owing to the development of the tactical use of the type and increased effective altitude, the pilot must be provided with wireless equipment, specialised flying instruments, oxygen apparatus, parachutes, etc., in addition to his guns. The net result is that the single-seater fighter of to-day is approximately the same weight as the two-seater aeroplane of ten years ago. Yet the modern single-seater fighter is more than 50 m.p.h. faster, has three times the rate of climb at 15,000ft., and has 10,000ft. higher Service ceiling than its counterpart of ten years ago.

A like measure of progress has been made in civil aviation, where the basic problem is in reality the same, *i.e.*, that of carrying the highest possible "pay load" for a given range with the minimum fuel consumption at a sufficiently high speed. In this case the problems of aircraft design are simplified by the absence of military requirements, although this is offset by the need for special

attention to questions of comfort, freedom from noise, and special facilities for easy and speedy maintenance.

These advances are the result of the progress which has been made in engine design, in aerodynamics, and in the manufacture and use of materials; each of these factors will be considered separately.

Aircraft Engines

In reviewing the present position of aircraft engines in this country one is impressed with the steady development that is taking place in every direction. A year or so ago it was often stated that water-cooled engines would quickly become obsolete. New types of water-cooled engines recently produced, however, justify the assumption that liquid-cooled engines will remain an important part of the Service engine equipment as far ahead as can be visualised.

In air-cooled types also it appeared that development of high-powered engines would be confined to the radial form, but the need for reducing head resistance has led to designs of in-line air-cooled engines, which show promise of successful development.

It has recently been realised—more particularly, perhaps, with air-cooled engines—that if the engine and aircraft are designed as one complete structure the result will be not only an increased performance of the machine but also, owing to the more favourable conditions in which the engine will be operated in respect to cooling, an increased period between overhauls and a general lessening of maintenance costs. Speed reduction gears are now fitted to many air-cooled radial engines, and, with the lower airscrew speed and consequently higher efficiency, general aircraft performance has been improved. The evolution of a satisfactory reduction gear for a radial engine makes possible, without loss of airscrew efficiency, that gain in output which is obtainable from a really high speed engine.

These somewhat general remarks will serve to show that in both the main classes of engines, air and water-cooled, the last few years have been years of progress, and that the immediate future of both types is assured.

Coming now to a more detailed examination of the actual engines it is perhaps in the application of super-charging to Service types that the greatest advance is apparent.

Although active research is proceeding with positive displacement blowers, so far it is those of the centrifugal fan type that have been actually embodied on production engines. The type has many obvious advantages, chief amongst which, perhaps, are lightness and simplicity, but whilst at low output pressures, up to, say, 5 lbs. per sq. in. (gauge) they are probably the most efficient when everything is considered, there is no doubt that when the demand comes for higher degrees of supercharge recourse may need to be made to the positive type.

In every supercharged engine so far developed the fan draws its air through the carburettor, and it is the petrol-air mixture that is compressed. This makes a simple installation well suited to the integral arrangement of the blower that is almost universal on engines to-day, but an alternative arrangement, in which compressed induction air is supplied to the carburettor, although entailing a pressure balance system applied to the carburettor, has certain advantages which warrant its serious consideration.

One of the most interesting advances is the increase in the compression ratio of standard engines with a corresponding all-round improvement in performance. Until comparatively recently a ratio of about 5 was considered to be the highest that could normally be used if the reliability of the engine were to be maintained, but to-day there are standard engines having a ratio as high as 7 and still proving as reliable as those earlier engines of lower ratio. This improvement has been the result of long investigation

into the problem of detonation as affected by the characteristics of the fuel used. It is only comparatively recently that the full significance of this effect has been realised, and even now the extent to which compression ratio can be increased must be limited by the quality of the available fuel. The use of "dope" in delaying detonation in high compression engines is now very widely resorted to, both benzol and tetro-ethyl lead being mixed with the standard aviation spirit for this purpose.

The modern supercharged or high compression engine is now required to pass a so-called "detonation test" prior to full type approval being given. This test consists of running the engine on standard Service fuel under the most severe conditions from the detonation standpoint—corresponding to the conditions of take-off of a fully loaded aircraft—without detonation occurring in excess of a pre-determined standard.

Steady development in this and in other directions has had the practical effect of a definite increase in engine performance generally, and as an instance of this improvement the case of the Napier Lion engine may be mentioned. Originally this engine was rated at an output of 425 b.h.p. at a normal speed of 2,000 r.p.m., whereas the Lion engine, which was successful in the last Schneider Trophy race, having exactly the same bore and stroke and number of cylinders, developed approximately 900 b.h.p. at a speed of 3,300 r.p.m., and this gain was accomplished with a definite reduction in both weight and frontal area. Even on standard Service engines a weight power ratio of about 1.5 lb. per b.h.p. is now being obtained.

It has been explained that the normal development of an engine is to meet Service requirements, but an outstanding exception is the design and production during recent years of the small, low powered engine suitable for light aircraft. The requirements of this class of engine differ entirely from those of a normal Service engine, reliability, low first cost and ease of maintenance being primary considerations, whilst weight and the obtaining of the highest possible power are of less importance. These characteristics necessitated an entirely new type of engine being evolved, and as typical examples of the class the Cirrus and Gypsy engines, designed by Major F. B. Halford, may be mentioned. These are air-cooled engines, having four vertical cylinders in line, and develop a power of the order of 100 b.h.p. The engines are particularly reliable, and a normal period between complete overhauls may be taken as about 400 hours, and in some cases a period of even 500 hours has been completed before complete overhaul was necessary.

Although not of any outstanding technical interest these engines represent the first real attempt to design an engine suited to the requirements of the "owner-pilot," and have proved so successful that they are in use in practically every country in the world in which there is civil flying, and their production must, therefore, be considered something of an achievement.

Coming now to engines of an entirely different type—the compression ignition or so-called Diesel engine—here again progress can be recorded. The Beardmore Tornado has recently satisfactorily completed a full 100 hours type test, and this represents the first attempt in this country to submit an engine working on the compression ignition cycle to such a test. The engine is an 8-cylinder in-line water-cooled type, developing approximately 600 b.h.p. at a speed of 1,000 r.p.m., and the average fuel consumption taken over the whole of the test was less than 0.4 lbs. per b.h.p. hour. The engine is admittedly heavy when considered from the heavier-than-air craft point of view, but it has of course been developed primarily for airship use.

There is no doubt, however, that from the knowledge and experience gained from these first engines, any future engines of the type that may be produced will prove lighter without any sacrifice of other essential requirements.

Apart from these large engines research has been proceeding on small single cylinder compression ignition engines, particularly with regard to high speed working and also to operation on the two-stroke cycle. It has often been asserted that really high speed on compression ignition engines is inherently not practicable owing to the very limited time available for the completion of the various phases of the cycle. This theory has, however, been proved to be unsound, as there is at present an engine running at a speed appreciably higher than 2,000 r.p.m., and at this speed developing a brake mean effective pressure of over 100 lbs. per sq. in., with excellent fuel economy.

From the results obtained on the two-stroke cycle, it is probable that engines of this type offer the most promising ultimate type of compression ignition engine for aircraft. The final form of the engine may not at present be apparent, whether of single or opposed-piston type, sleeve valve or "crankless," but if for no other reason—now that it has been established that high outputs with good economy can be reached with a two-stroke cycle engine running at high speed—the resultant low power-weight ratio makes this type particularly suitable for aircraft.

No survey of the present position of aircraft engine research would be complete without reference to the high speed sleeve valve engine. The sleeve valve is in many ways a most attractive feature, but the difficulties in design involved in its application to light weight aircraft engines are immense. It is in no small measure due to the pioneer work of Mr. H. R. Ricardo, involving as it has years of fundamental research, that a stage has now been reached when the high speed sleeve valve aircraft engine appears to be a practical possibility.

In the limited time available it has only been possible to give a very brief outline of the present position of aircraft engines in this country. Sufficient has, however, been said to show that during recent years progress in all directions has been maintained, and that to-day, from standard engines, performances are being obtained which a comparatively short time ago would have appeared to be impossible. There are production engines flying to-day that develop their rated power at an altitude of approximately 15,000ft., and as an indication of the increased reliability that has been obtained, it may be mentioned that many Service engines are now running for periods up to 400 hours between overhauls. This is a fact of the greatest importance when considering the maintenance of flying services, especially when, as is the case, it is accompanied by a big fall in the percentage of engine failures.

It has also only been possible to indicate some of the many lines of research at present being followed, and those that are nearing the stage of practical development have been chosen as being of more immediate interest. In this connection mention must be made of the work now being done in the investigation of the possibilities of using home produced fuel for Service purposes.

There are successful laboratory methods of producing motor spirit from coal, but, unfortunately, serious difficulties arise when large scale production is attempted, and the main problem is that of producing suitable fuel of uniform quality at an economic price.

Aerodynamics

Of recent years much progress has been made in our knowledge of the factors on which aerodynamic efficiency depends. Thanks to the work of Prandtl, Lanchester, and others, the properties of aerofoils are more perfectly understood (or shall I say less imperfectly understood?), and more complete consideration can now be given to the choice of aerofoil and aspect ratio in the light both of structural and operational considerations, and of the desired performance characteristics.

Structural considerations and the tendency to bigger span have led to the development of " semi-thick " and " thick " wings, which are being used even for biplanes. The earlier " thick " wing sections, whilst giving adequate spar depth for the elimination, or, at any rate, reduction of external bracing, suffered from high drag characteristics and from large movement of the centre of pressure, the former reducing performance and the latter involving excessive weight and undesirable flying characteristics.

Modern aerofoil theory has paved the way to the development of aerofoils of low drag and small centre of pressure movement coupled with adequate spar depth, and these are now in general use. The development of suitable aerofoil sections has again directed attention to the monoplane, which, on account of the problems associated with the structure and control, has been rather neglected in this country. The merit of the monoplane is now being thoroughly explored, and several monoplanes of relatively large size are under construction.

Concurrently with the development of aerofoils, great attention has recently been paid to the refining of the design of components, reduction of engine drag, and elimination of as much external drag as possible, all of which make for better performance for the same horse-power. At the present time a co-ordinated attack is being made on the problem of reducing interference drag, and good results have already been secured in respect of reduction in the drag of radial engines.

The rapid development of engine design and the raising of crankshaft revolutions have also had their effect on aerodynamic research, and considerable progress has been made in airscrew theory and design. The increasing engine revolutions have brought their attendant troubles, particularly from the civil aspect, where airscrew noise is a cause of grave discomfort to the passengers. This problem is being energetically attacked at the present time.

As an indication of the rapidity with which progress has been made in the above directions the following figures are of interest. During one year's development of a high speed aircraft the top speed was raised some 70 m.p.h., and analysis shows the various factors contributed as below.

(1) Reduced head resistance	37 m.p.h.
(2) Increased horse-power	20 m.p.h.
(3) Increased airscrew efficiency	9 m.p.h.
(4) Increased landing speed	4 m.p.h.
	70 m.p.h.

Structures

The ever pressing need for making aircraft more efficient weight carriers, of increasing their useful life under widely varying climatic conditions, and of reducing maintenance and simplifying repair, has enforced steady progress in structural design, but the chief advance has been in the development of all-metal aircraft. This development has involved the introduction of new materials and new methods of treatment, the provision of new equipment in the aircraft factories, and the training of personnel in a new technique. All this has been accomplished; metal construction is now definitely established, and all the principal factories are equipped to design and produce metal aircraft.

The metal aircraft is, of course, not new, but in the early days the metal was used in the form of tubes, whose properties were well known, and whose use was common in ordinary structural engineering practice. The objection to the use of tubes for aircraft structures is that no great saving in weight is possible because of the difficulty of developing the maximum stress of the material in thin-walled tubes when used as a beam.

As a result the use of tubes is to-day chiefly restricted to fuselages, interplane struts and under-carriage members, though small wings and tail planes have been produced satisfactorily using tubular spars. Sometimes these have been specially drawn tubes, but they are heavier than those produced by more refined methods.

The full advantage of metal construction has been obtained with the advent of

(1) Methods of using thin strip metal;
(2) Reliable light alloys.

Both these methods have now been highly developed in this country, but until recently the chief success had been obtained from the use of high tensile steel strip. The essential feature of strip design is the method adopted to prevent secondary failure before the full strength of the material is developed. This has been attained by corrugating the metal along the length of the members.

Structural members in light alloys can be made of thicker sections without loss of efficiency, and the difficulty of overcoming secondary failure is thus greatly reduced. Partly owing, however, to lack of knowledge of their properties, to corrosion troubles and to the fact that they are liable to fatigue failure, the use of light alloys for structural parts has not been very extensive in the past. Now, however, their use has been developed, and duralumin wings are being used successfully.

The advantages of the strip method can be summarised as:—

(*a*) Appreciable weight saving is possible. In large sizes, for example, a strip steel fuselage has been shown to be about 15 per cent. lighter than the corresponding component in tube.
(*b*) The method, when understood, lends itself to mass production.
(*c*) A large range of design conditions has already been investigated, and spars are available up to 15in. in depth at a weight considerably less than the corresponding wooden member.

The other way in which metal is used is in the form of sheet. Sheet has only been used in this country for fuselages, hulls and floats, but its value as a wing covering is now being investigated.

Duralumin sheet has become the standard material for seaplane hulls and floats, and considerable success has been achieved. Components can be built which are stronger and more easily maintained than wooden ones, and which, in addition, have the great advantage that they eliminate water soakage. Coupled with these advantages is the fact that they are some 20 per cent. lighter than the equivalent wooden units.

The metallurgical research which is responsible for these new methods of design is worthy of consideration in some detail.

Metallurgical Research—(1) Steels

As a result of research and investigation marked changes in aircraft structural steels have been achieved.

It has been found possible to utilise the high strength properties of certain nickel-chromium steels in the form of strip sheet and tubes having an ultimate stress up to 85 tons per sq. inch, and 0.1 per cent. proof stress in the range 40-65 tons per sq. inch, with reasonable ductility. This class of material is capable of being formed to some extent in the hardened and tempered condition, but may also be formed in a soft condition, and long sections can be heat-treated by passing through hot dies as a final operation.

In view of the attractiveness of welding from the production point of view a considerable amount of investigation and research work has been undertaken on welding steels. It is well known that ordinary low carbon steels can be welded easily and for many purposes satisfactorily, but that the properties of

the welds are improved greatly by "normalising," an operation which is not practicable on large structures. Practical experience has indicated that failures of welds in low carbon steels have occurred more frequently in un-normalised welds than in normalised.

Investigations have shown that certain manganese steels, in addition to having attractive mechanical properties, are useful materials for welding and much to be preferred to plain carbon steels on account of comparative freedom from air-hardening by rapid cooling of the welds; the ductility of the steels as welded also remains high in comparison with that of other steels. An extensive programme of work, including endurance tests under fluctuating stress, is being undertaken to discover means of selecting steels for high strength welds.

In view of the high cost of reconditioning, and of maintaining metal parts of aircraft which are protected by paints, varnishes, and similar preparations, attention has been directed towards the protection of parts made in ordinary steels by zinc and cadmium deposits. As a result of lengthy investigations, protective coatings of zinc and cadmium applied by electrodeposition have proved capable of useful application. The performance of streamline wires, tie rods, and similar components appears likely to be improved considerably by this form of treatment, and, moreover, storage difficulties are reduced. Zinc coatings produced by hot diffusion processes have also been developed with satisfactory results. Researches into the influence of these coatings on the so-called corrosion-fatigue properties of the basis metal are in progress.

The general desire for materials having intrinsic properties rendering them resistant to corrosion under the variable atmospheric conditions in insular climates has resulted in the rapid development of the non-corroding types of alloy steel, and as instances of the advances made in this direction by application of the results of experimental work and the exercise of a high degree of skill by manufacturers, non-corrosive steel strip having 0.1 per cent. proof stress of 65 tons per sq. inch, tubes of 50 tons per sq. inch, 0.1 per cent. proof stress, and sheets of 55 tons per sq. inch, 0.1 per cent. proof stress may be mentioned.

On account of high resistance to oxidation at high temperatures, steels of the high-nickel, high-chromium type are finding useful application in valves, superchargers, exhaust manifolds and pipes, etc., of aircraft engines. A programme of work on steels for use at high temperatures is being prepared with a view to removing some of the present difficulties experienced in aircraft engine work.

Special attention is being paid to the problem of welding the non-corrosive types of alloy steel. The investigations have included arc welding methods of the usual types, acetylene welding, and the Langmuir hydrogen-flame arc method. In all welding operations on these steels difficulties arise owing to the tendency for the steels to develop oxide films which, though small in amount, are strong, tough, and not readily dissolved by the fluxes ordinarily used. The experiments have indicated that the usual forms of arc and electrical methods of welding do not lend themselves conveniently to the general work of aircraft production and are not operated to best advantage on the thin sheets and strip materials.

(2) *Light Alloys*

Experimental work on wrought aluminium alloys has been directed towards obtaining sound ingots in comparatively large sizes and to a number of corrosion problems.

In the production of wrought light alloys, as also of other metals, the soundness of the original ingot is a factor of high importance in relation to the properties of the final product. Attention is being paid to the method of melting the alloys, temperatures of metal and mould, rates of casting and of cooling, etc.

Owing to its high strength at high temperatures and other suitable properties, Y alloy has proved an excellent material for aircraft engine pistons. Forged pistons made from discs of Y alloy are widely used, and forged cylinder heads for air-cooled engines are a more recent development. At the National Physical Laboratory, where this alloy was originated, experiments are being made on the influence of several special elements, iron, silicon, etc., when present in the alloy in varying amounts and similar experiments are being made with duralumin.

Special attention is being paid to the problems associated with the low resistance to corrosion of aluminium, magnesium, and alloys of these metals with others. A research on the corrosion properties of wrought light alloys is being conducted with particular reference to intercrystalline corrosion of duralumin and other wrought alloys. The results of attack by reagents likely to be capable of producing intercrystalline breakdown of aluminium alloys are being observed in order to develop methods which can be used to produce it quickly in samples prone to this type of deterioration. Experiments have indicated that material softened by heating to a temperature below 400° and quenching is more susceptible to intercrystalline corrosion than finally heat-treated and aged material, and that overstrain is an important factor.

The method of protecting aluminium and its alloys from corrosion by the formation of an anodic oxidation film is now widely employed in this country. Experiments are being continued with the object of preventing deterioration of the electrolyte in order to secure satisfactory running of industrial plant over long periods.

Investigations on the prevention of corrosion of magnesium have been made with the object of reducing the tendency to corrode by alloying magnesium with other metals and also with the object of producing protective films. A simple immersion process has been evolved, which, in conjunction with application of an appropriate enamel or grease, gives a very fair measure of protection. Laboratory corrosion tests, beach exposure tests, exposure tests on marine aircraft and corrosion-fatigue tests are being made to determine the effect of the treatment.

It has been established that the soundness and general properties of aluminium alloys can be improved substantially by " pre-solidification " of the molten alloy or by treatment with nitrogen gas. In the pre-solidification process the molten alloy is allowed to cool just far enough to become completely solid in the crucible and is then remelted quickly and cast. The nitrogen treatment consists in bubbling nitrogen through the molten metal for a short time before the latter is poured. Both processes may be applied with advantage. A number of large castings are being made and examined for information on the results of the treatments as carried out on a large scale.

An account has been given of the more important factors contributing to the rapid increase of the performance of aircraft. The results of research directed towards increasing the safety of aircraft are not less noteworthy.

Safety Measures

The chief factors detrimental to the safety of aircraft are:—

(1) The loss of control which results when the aircraft loses flying speed;
(2) The slowness with which some types recover from a spin.

As regards the former, consideration of landing in restricted spaces and accidents due to inadvertent stalling have, during the past few years, focussed attention on stability and controllability at and even beyond the stall.

The difficulty arises, of course, from the important characteristic of conventional ailerons that at large angles of incidence they are ineffective in raising a dropping wing, give instability laterally, and introduce a turning moment in the sense to increase the already existent turn. As a result attempts to raise

a dropped wing when an aircraft has been inadvertently stalled only induce a spin which leads to a "crash" if the stall occurs close to the ground.

Much research has been directed towards this problem, and a solution has been found in the association of a Handley Page slot and normal aileron. For some aircraft a simple form, in which the slot is opened automatically by the air forces acting on it, gives all that is requisite in practice, and this is being generally adopted. For the highly manœuvrable types, whilst the auto-slot removes danger from the stall, the control is not enough, and methods of linking the auto-slot with the aileron are being explored in order to get the degree of control which is necessary.

The problem of the spin has been closely investigated, and the factors involved in the early stages are now partially understood. Difficulties have been met, however, on certain aircraft where recovery from the spin becomes troublesome when the aircraft has been given time to settle into a steady state. Full scale experiments have been made, and a comprehensive programme of wind channel research involving new departures in wind channel technique has been instituted. Although the work is not very far advanced sufficient is already known of the factors involved to ensure that aircraft shall recover reasonably well from prolonged spins.

Another research having the object of increasing the safety of aircraft is the examination of the fundamental factors associated with wing flutter which certain aircraft have exhibited at high speeds. The nature of the case is now understood, and efforts are being made to present the result of the researches in such a way as to be capable of direct application by the designer.

However successful we may be in solving control and spinning problems, the fact that conventional types of aeroplanes depend for sustentation on translational motion at comparatively high speeds will always be a potential source of danger in certain circumstances.

An alternative, the rotating wing aircraft, has been vigorously studied in this country. After the War certain experiments with helicopters were begun, but no material success was attained until the advent of the now well-known autogyro, the invention of Senor de la Cierva, with its ingenious and attractive system of hinged blades. A number of these aircraft have been built and we now have a rotating wing type of aircraft capable of flying long distances with a useful performance. In its present form, however, it would appear that we must accept a drop in top speed, rate of climb, and fuel economy in order to reap the great advantages of the autogyro in respect of safe landing.

If the rotating wing should fail to attain all its ideals through the autogyro, it is possible that success may be achieved through the Isacco helicogyre. This machine is an autogyro in which each of the four blades carries a small engine and airscrew. One is being built in this country and is expected to be ready for flying tests this year. Such a machine, if it flies at all, should be able to ascend and descend vertically. If it did this successfully, at not too great an economic cost, it would have merits with which the conventional type of aircraft, slotted or otherwise, would find it difficult to compete. The path is likely to be long and difficult, but we cannot go forward with the conventional type of aeroplane with complete confidence that we are on the right path, if we leave behind us uninvestigated the potential qualities of the rotating wing.

The increased performance of modern aircraft and the ever increasing duties imposed upon them, has demanded an intensification of research on aircraft equipment, hardly less in extent than that expended on the design of the aircraft itself. No account of aeronautical development in this country is complete without a consideration of the results which have been achieved in this direction.

Aircraft Instruments

The main objectives of research on aircraft instruments are increased accuracy at all temperatures likely to be encountered, augmented range and a reduction in weight and bulk. A few examples will illustrate what has been achieved.

An altimeter ranged to 30,000 feet is now accommodated in a case which occupies little more than half the dashboard space of, and is one-third less in weight than, previous instruments. An airspeed indicator ranged to 240 miles per hour and weighing 11 oz. has a case $3\frac{3}{4}$ in. in diameter. Altimeters have been produced in quantity with an instrumental error of only 100 feet at 20,000 feet, while the airspeed indicator is accurate to within about two miles per hour at 240 miles per hour over a temperature range of minus 30°C. to plus 40°C.

Again, the bulk, weight and cost of the well-known F.8 automatic film camera has necessitated the development of an entirely new design. The older camera occupied about two cubic feet and weighed 70 lbs. complete as loaded for 100 7 in. square photographs. In the new type the bulk has been reduced by two-thirds and the camera weighs 30 lbs. as loaded for 150 5 in. square photographs.

Recently attention has been focussed on the need for rigid economy of fuel during long distance flights, where the fuel of necessity accounts for the bulk of the load carried. Attempts to ascertain the normal consumption in flight revealed the fact that, when the manual altitude control to the carburettor is used, widely different consumptions are obtained by different pilots on the same aeroplane and even by the same pilots on different flights. The need arose, therefore, for an accurate fuel flowmeter. The problem was attacked from first principles and a satisfactory instrument, on view at this Exhibition, has been evolved.

Tests under Service conditions illustrate the value of the instrument for the purpose of economising fuel. Five aeroplanes were flown in formation at a height of 15,000 feet for two hours, and the specific fuel consumption in each case was estimated from a measurement of the total consumption. No flowmeters were used for this test. In other tests the same aeroplanes equipped with flowmeters were flown under similar conditions. The results are best illustrated by a comparison of the specific consumption of each aircraft with the lowest figure obtained during the tests. Expressed as percentages of this optimum figure, the excess consumptions were never more than 7 per cent. with flowmeters, whereas they were 27, 29, 32, 36 and 60 per cent. without flowmeters.

Turning now to the electrical equipment of aircraft, refinement of design and careful selection of material has made it possible to equip a single-seater fighter, for example, at an expenditure of weight 55 per cent. less than that needed during the late War. The conventional four-lamp scheme of navigation lamps has been replaced by one in which two tri-coloured lamps are used and considerable economy of weight and power thereby effected.

The troubles experienced with oxygen breathing apparatus at high altitudes have been removed by the use of a specially designed reducing valve and an electric preheater for preventing even the very small amount of moisture present in the commercially dry oxygen from causing stopping by freezing. The safety of high-pressure oxygen apparatus has been increased by the use of very light alloy steel cylinders, proof against shattering even under the impact of armour-piercing bullets. Liquid oxygen apparatus has been continuously and successfully used in almost all the high altitude flights.

Finally, there are a number of special instruments intended primarily for tests of controllability and other aerodynamic research purposes. The position of any control surface is recorded continuously on a light-sensitive film by an

instrument attached to the tail unit or wing; several of these records may be synchronised by a common clock controlling the lamp circuits. A recording control column measures the moment applied to the surface as desired, and a three axes gyroscopic turn recorder measures the three components of the instantaneous angular velocity. A three axes angular acceleration recorder of sufficiently high frequency is also in view, and a single axis unit having a frequency of five oscillations per second and covering the range 1 radian per second per second has been constructed.

A rate of descent meter consists of a special hot wire anemometer placed in the pipe line connecting a thermally insulated capacity chamber with a static head. This instrument is capable of giving readings of rate of descent to one foot per second with a lag of about half second. A recording instrument has also been made in which a shadow of the galvanometer needle is recorded photographically at intervals of one-fifth second.

An automatic observer comprising a small cinematograph camera provides a record of the readings of several dial instruments on a single film.

As an example of research directed towards meeting the operational demands made upon aircraft, an account will be given of the progress made with the use of wireless apparatus on aircraft.

Wireless

Since the War the long wave equipment, which is used for long distance working both in military and naval aircraft, has not changed in principle though the design has been improved in detail, giving reduction in weight, higher efficiency and greater operating conveniences. The wave length range of this equipment is from 1,000-2,000 metres and ranges in excess of the flying range of the aircraft are obtained, using a trailing aerial.

The spark transmitter, which was used so extensively in the War for artillery observation and similar purposes, has been replaced by a more modern valve transmitter which emits modulated continuous waves. By a suitable arrangement a switch is provided so that the frequency of the note modulation may be varied, thus facilitating the recognition of signals from individual aircraft. In recent years some considerable attention has been directed towards the use of short waves of the order of 50-120 metres for aircraft communication. The advantage of the use of wave lengths of this order is that it enables the trailing aerial to be abandoned in favour of a fixed aerial system arranged on the aircraft. For military use this is a very great advantage as it allows the aeroplane to manœuvre and fight quite freely and relieves the pilot or observer of the necessity of letting out or reeling in the trailing aerial.

The equipment, as developed for single-seater fighters and similar duties, operates on a wave length range from 40-120 metres; the design which is on conventional lines calls for no special comment.

Of recent years the development of civil aviation has caused a demand for radio equipment suitable for use in civil aircraft to enable them to maintain communication with their terminal air ports. The value of such an equipment was very soon realised and a radio installation is now carried on all regular commercial aircraft except in some of the smaller aircraft operating on occasional services. The wave length laid down by international agreement for the civil air service is from 850-950 metres, and various forms of complete equipment for use in civil aircraft have been produced by Messrs. Marconi's Wireless Telegraph Co., Ltd., examples of which are to be seen in the Exhibition. Messrs. Graham Amplion, Ltd., are also exhibiting experimental equipment fulfilling similar purposes. This equipment, it is understood, will not be available to the public before 1930.

The use of the shorter wave lengths for long distance communication on civil aircraft is also receiving some attention, and Messrs. Marconi's supply equipment covering the wave length range of about 80-120 metres, intended primarily for military use, while it is understood that Messrs. Graham Amplion, Ltd., are also developing similar equipment covering a wave length of from some 20-100 metres.

A further important use for radio communication in connection with aircraft is that of navigation. For this purpose the Royal Air Force, or Robinson System, was developed in which, by means of an installation of crossed coils in the aeroplane, the operator is able to determine the bearing of any wireless station with respect to the aircraft. This system of navigation has the advantage that the aircraft can make use of any convenient wireless station that is transmitting, but the disadvantage that extra equipment and specially trained operators are required.

A further system for aiding navigation consists in having two or more ground direction finding stations, which on demand from an aircraft equipped with a radio transmitter, will take a bearing on this aircraft. These stations are usually grouped under a common control where the bearings obtained are correlated and the position of the aircraft determined and transmitted to the pilot. This system has the objection that it requires the aircraft to be equipped with both a transmitter and a receiver and requires a certain amount of formal signal organisation. This is the system at present in use for the civil air routes and is also used by the Royal Air Force to a certain extent.

As a result of a considerable amount of research, a system has been developed which requires only a receiver on the aircraft and enables an aircraft to determine its position wherever it may be, provided only that it is within the range of the transmitter. The system employs on the ground what is termed a rotating beacon. This is a transmitter consisting of a simple loop the radiation of which has the characteristic figure 8 polar diagram. The loop is rotated at a constant speed of one revolution per minute. It transmits a characteristic signal when in the north and east position. If an aircraft receives the north signal from the beacon and notes the time which elapses between the transmission of this characteristic signal and the receipt of the minimum signal the bearing of the aircraft from the beacon is immediately obtained by multiplying the time in seconds by six. An installation consisting of two or more such beacons enables an aircraft, without having to transmit, to determine its position whenever it is in range of these beacons. The advantages of this system are that any aircraft equipped with a receiver can obtain its position whenever the beacons are working. No special arrangements or organisation as between the aircraft and the beacons are required. The same beacons would also serve for ships at sea should their sites be suitably chosen.

AN HISTORICAL SURVEY OF ITALIAN AERONAUTICS

BY

R. GIACOMELLI

A Paper Read on behalf of the Author by Mr. M. L. BRAMSON before the Royal Aeronautical Society at Olympia on July 25, 1929.

FOREWORD

In the development of Italian aeronautics four periods can be distinguished:

A first period, covering the 15th, 16th and 17th centuries, in which the first idea of the technical possibility of human flight, both on the heavier and on lighter than air principles, was conceived in Italy and the physico-mechanical conditions of animal flight explained. In this period are to be met the names of Leonardo da Vinci, Francesco Lana and Alfonso Borelli working on independent lines.

A second period, in which Italy produced a number of distinguished aeronauts, among whom Vincenzo Lunardi and Francesco Zambeccari became well known in England for having carried out in London the first balloon ascents in 1784-85. In this period, which, starting with the discovery of the brothers Montgolfier, does not go farther than the first decades of the 19th century, Italy did not combine with an interest in practical air navigation any actual scientific contribution to its development.

A third period, in which Italy entered the scientific field. In this period, which covers the time from the last twenty-five years of the 19th century to the end of the Great War, we find two principal names:—Enrico Forlanini and Arturo Crocco.

Finally the present period, subsequent to the war.

CHAPTER I.—THE FIRST SCIENTIFIC IDEAS OF HUMAN FLIGHT

On the work of Leonardo da Vinci on human flight a definite opinion can now be expressed. He arrived, after a long evolution of ideas, at the same solution which humanity actually realised towards the end of the past century with Otto Lilienthal in Germany, and his successors in several countries: Pilcher in England, Ferber in France, Chanute and the brothers Wright in America. In fact, Leonardo da Vinci, having started, like Lilienthal, from the imitation of the flapping flight of birds, came, at the end, like the latter, to soaring flight. The difference between the two lies in this:—Lilienthal was driven from flapping to soaring, or rather gliding flight, through *practical* experiments; Leonardo da Vinci, who never attained to actual construction and tests, through *mental* experiments.

Figs. 1 and 2 represent two models, now for the first time constructed, of two flying machines of Leonardo da Vinci, in the first stage of his evolution, when he thought to imitate the flapping flight of birds. In the first machine (Fig. 1) the man was to be lying face downwards; the wings are attached to his shoulders and fixed to his body with a girth. By extending his feet, set in two stirrups, the man brought down the wings, which were raised through his hands by means of two handles. It must be observed that in both these models, according to the drawings which Leonardo made, only the central axis of the

skeleton of the wings is reproduced. In fact, Leonardo did not usually draw all the wings, but only the central axis, to avoid complication in his sketches.

In the second more perfected machine (Fig. 2), the man has his hands completely free, all the movements of the wings being effected through the feet. The man is lying on a wooden board to which he is attached by means of a metallic ring passing under his armpits and a leather strap round his waist. By pressing with one leg on a pedal the wings were raised, the other foot lowering them, while they automatically varied to a certain extent their incidence and amount of extension.

FIG. 1.

Leonardo da Vinci's machine for attaching to the shoulders.

But later Leonardo understood that the position of the man lying was not fully convenient for various reasons and that a machine in which the man's position was upright would be better.

Leonardo designed a machine with the man upright, but he did not go into it in great detail, so that of this no model has been reproduced.

This first period of Leonardo's work, to which these flapping wing machines belong, ranges from 1486 to 1490.

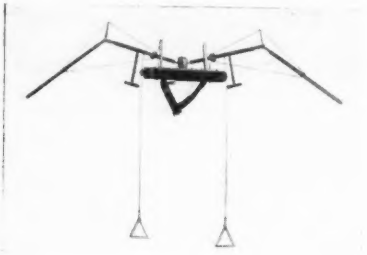


FIG. 2.

Leonardo's second machine, to be operated by a man lying prone.

Fifteen years later, in 1505, Leonardo da Vinci conceived flying machines where the motions of the wings effected by the man, by means of his hands and feet, no longer produce propulsion and lift, but rather direction and balance according to the wind, the latter being the actual agent of the flight.

No complete drawings or descriptions of this new machine have been left by Leonardo da Vinci, but collecting and comparing in a reasonable way some passages and partial sketches from the so-called "Codex on the Flight of Birds," it has been possible to form a general idea of it. The machine was to

be of very great span, of high wing monoplane type with the centre of gravity very low. A pastel picture of this hypothetical machine of Leonardo da Vinci has been exhibited at Olympia. With this "famous bird," as Leonardo da Vinci named it, he hoped to start his "great flight" from Mount Ceceri, in the spring of the year 1505, "filling with amazement the whole world and bringing eternal glory to the place where he was born." Mount Ceceri is a hill 1,370 feet high near Florence, where Leonardo, in his own words, was a witness of the soaring flight of the great birds of prey.

From the beginning of the 16th century we come to the end of the 17th century before finding the first scientific idea of flying with static sustentation.

At Olympia a model was exhibited of Francesco Lana's aerial ship sustained by means of four hollow copper balls emptied of air. It is interesting to observe that this year there has been republished in Italy a forgotten Latin poem

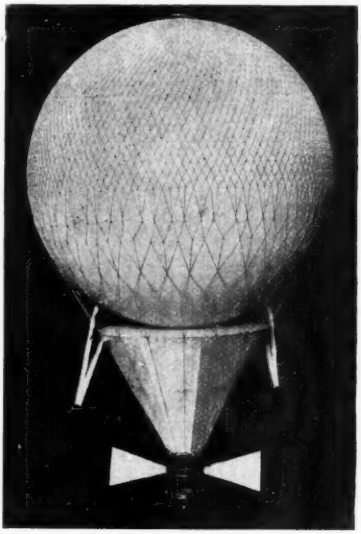


FIG. 3.
Francesco Zambeccari's Balloon, 1803.

printed in Rome in 1768, by a scholar, one Bernardo Zamagna, who, starting from Francesco Lana's project, sang with elegance of poetic form and correctness of scientific concept, of the possibilities and advantages of aerial navigation, 15 years before the invention of the brothers Montgolfier.

As regards Alfonso Borelli, his studies on the flight of birds are well known. The modern French scientist, Marey, said that his own discoveries on the matter had been anticipated by Alfonso Borelli.

CHAPTER II.—AEROSTATION IN ITALY AFTER THE INVENTION OF THE BROTHERS MONTGOLFIER

Of this period very little can be said from the scientific point of view. Fig. 3 shows a photograph of a model of Francesco Zambeccari's machine, which has now been constructed and was exhibited at Olympia. It consisted of a balloon filled with hydrogen to equilibrate the machine and of a bag with hot air below, to regulate the lift of the same. A feature of this machine was a

device consisting of a metallic ball tied to a rope to lower to the ground in landing to diminish the rate of descent. Zambeccari was the first Italian martyr of flight.

It is also worth mentioning that in these first years of aerial navigation, the first aeronautical magazine of the world appeared in Italy. It was the "Giornale Aerostatico," three numbers of which were printed in Milan in 1784; after these, lack of support compelled the magazine to come to an early end. Evidently the world was not yet ripe for an aeronautical monthly paper!

Chapter III.—Scientific Researches from the End of the Nineteenth Century to the End of the Great War

The scientific movement in aeronautics in the 19th century started in Italy later than in other European countries.

Eng. Enrico Forlanini constructed in 1877 a steam engine helicopter model which rose 40 feet above the ground (Fig. 4). In 1855 the same inventor con-

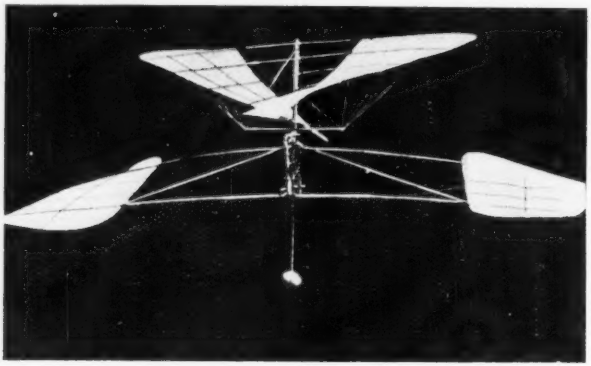


Fig. 4.

Enrico Forlanini's steam-driven helicopter, 1877.

structed a model of an aeroplane, to take off after running along two steel wires, propelled on the reaction principle by a gunpowder tube. Another interesting feature of Eng. Forlanini was the construction of a hydroplane or hydropter, a machine utilising the same principle of dynamical sustentation as the aeroplane, except that its very small wings operated on the water instead of the air. The patent of this machine, which ran very successfully on Lake Maggiore, was taken out in 1904. Considering that at that time taking off was, for aeroplanes, one of the most serious problems, we can see why Eng. Forlanini conceived the idea of utilising the run on the water by hydroplane wings in order to obtain a sufficient velocity to fly. Thus, besides its use as a boat, the hydroplane was conceived by Eng. Forlanini as a stage for passing to the aeroplane. The original helicopter and aeroplane and a model of the hydroplane of Forlanini were exhibited at Olympia. After the hydroplane Eng. Forlanini studied, with the collaboration of Captain Dal Fabbro, the airship.

The first airship of Eng. Forlanini, of the semi-rigid type, 132,150 cu. ft. in volume, with a steam engine, the "Leonardo da Vinci," flew in 1909. It was an experimental type and demonstrated the accuracy of its constructive basis. It was followed by another airship, "The Citta di Milano," of 421,400 cu. ft., which flew in 1913 and burst after a landing in the open country. The English Admiralty ordered three of this type, and Eng. Forlanini began the

construction of this third type of 500,000 cu. ft. airship for England. When the war broke out the English order for the Forlanini airship was cancelled, and it was taken over by the Italian Army, for which Eng. Forlanini constructed, during the war, three other airships, leading up to the F.6.

The studies of Eng. Forlanini on airships and the progress made in France with the Lebaudy type, aroused the attention of the War Ministry, which in 1906 ordered the so-called Specialist Brigade of the Engineer Corps (in which Captain Crocco, with his collaborator, Ricaldoni, had some years earlier started aeronautical researches and studies) to construct a military dirigible. From their studies was evolved the first experimental airship of 90,000 cu. ft., which flew in 1908, before that of Forlanini. This was followed in 1909 by an improved type, and then started regular construction in two sizes: the P. (small) type of 180,000 cu. ft. and the M. (medium) type of 430,000 cu. ft.

The construction of the semi-rigid type of Crocco and Ricaldoni is well known in England in all its details, among which are the articulated keel, the automatic rudders, the free hinge and variable pitch propellers, the bow stiffening, the automatic valve, and so on. In fact, England bought an " M." type airship during the war.

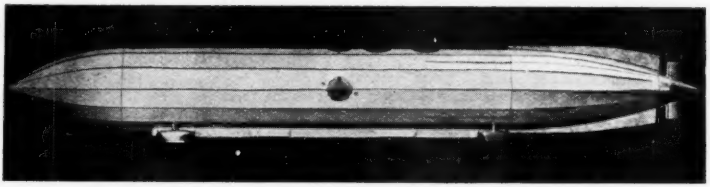


FIG. 5.

" G " type rigid airship projected during the War.

Similarly well known are the Crocco apparatus for deriving the shape of the cross section of airship envelopes and the Crocco method and apparatus for determining the deformation of airship envelopes by experimenting on water-filled models, the model envelope being made of the same material as the full size airship envelope. Both these apparata were exhibited at Olympia.

Italy entered the war with the military " P." and " M." type and the Forlanini airships.

During the war, at the end of 1915, the " M." type was lightened in order to obtain a greater " ceiling," and the " M.A." produced. A model of the car of this type was exhibited at Olympia. It carried a 1.5 inch gun.

It is interesting to note the great efforts made in Italy during the war to develop guns for airships, and also aeroplanes. The firing table for aerial guns was calculated by the famous mathematician, Prof. Volterra, and by Prof. Audreoli, in collaboration with A. Crocco in this matter. An automatic device for aiming and a route indicator were developed by Crocco and E. Prassone, which were exhibited at Olympia, and at the end of this great effort for aerial armament, a flying bomb was realised in 1918 by A. Crocco, with the collaboration of the late Gen. Guidoni, of which the Armistice prevented the use. This device was for the first time shown to the public at Olympia.

In 1916, with the object of obtaining higher speed, a new airship type was constructed by Gen. R. Verduzio, the " V." type, of 560,000 cu. ft.; followed in 1917, for scouting purposes, by the " E." type of 100,000 cu. ft. in imitation of the Engilsh S.S., and, in 1918, by the " O." type of 130,000 cu. ft., designed by Col. D. Pesce. After the war a large airship of 1,200,000 cu. ft., designed by Crocco, Nobile, Prassone and Usuelli, was constructed and sold to America,

the " Roma." This construction served to demonstrate the possibility and convenience of the semi-rigid type in large sizes, which, till then, had been denied. In 1921, A. Crocco projected a still bigger semi-rigid airship, the " T." (Transatlantic) of 4,300,000 cu. ft., having a range of 12,500 miles, a cruising speed of 62 miles an hour, with a disposable lift of 36 tons, for passengers, mail and freight, but this has never been constructed.

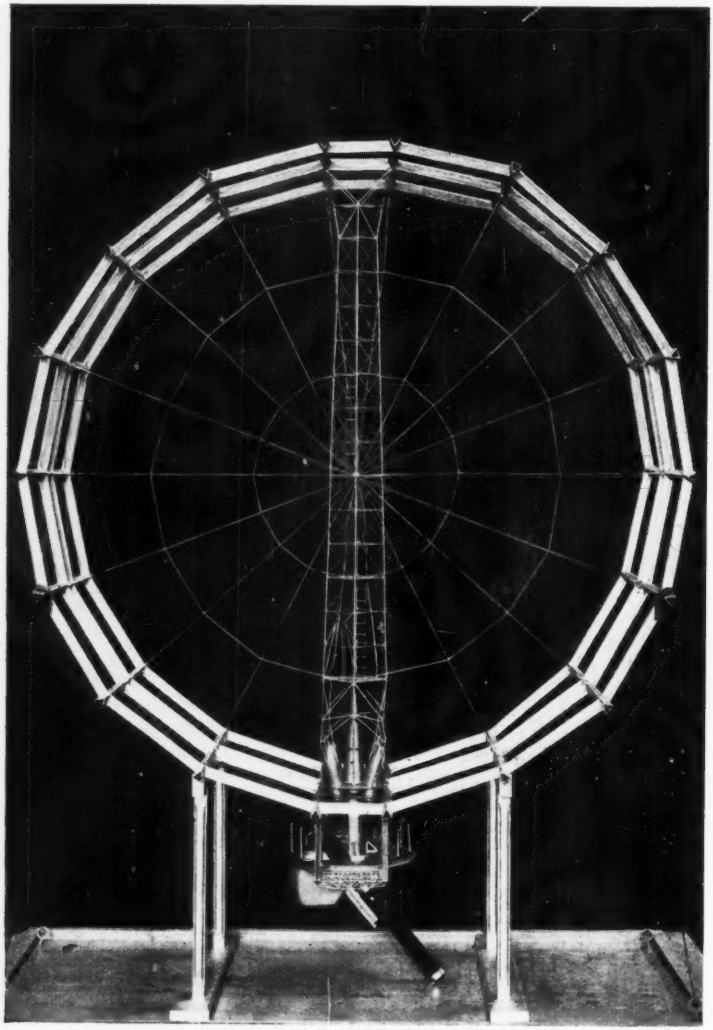


FIG. 6.
Section of " G " type showing gun-tube.

The " Roma " was followed in 1923-24 by another airship, the " N." type, designed on the same lines as the projected " T." by General Nobile, of 66,000 cu. ft., with three Maybach engines giving 750 h.p. and a maximum speed of 73 miles an hour.

The " N." type, in which U. Nobile employed very great accuracy in construction, has proved the last Italian airship, because, as you are probably aware, Italy renounced two years ago the construction of more airships, devoting all its technical and financial resources to the construction of aeroplanes.

Before closing the subject of Italian airships, it is worth mentioning that, notwithstanding the fact that the semi-rigid type has been the national Italian type, Italy studied also the rigid type and a complete project of it in all its details was made in 1913 by Gen. Crocco, with the collaboration of Eng. Anastasi, Costanzi and Prassone. This was the rigid airship known as the " G." (Great)

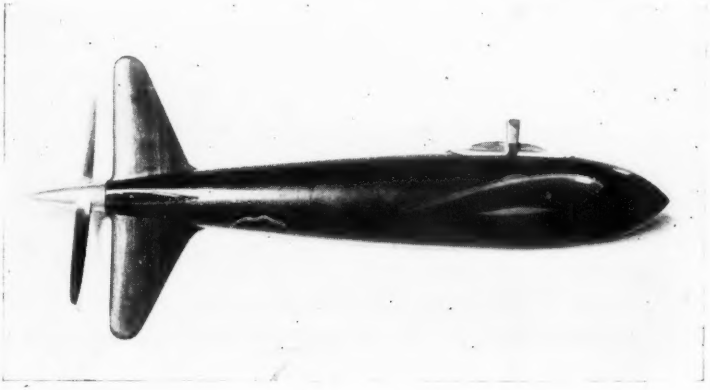


FIG. 7.

Model of Crocco's variable incidence monoplane, 1903.

type, of 1,430,000 cu. ft., very large for that time, the Zeppelin airship having arrived only at 230,000 cu. ft. Its construction was begun when the war broke out (Fig. 5 and Fig. 6). Italy at that time had no suitable material for its construction, and this had to be supplied by Germany, where drawings of the airship had been forwarded for the preparation of the material. The war having broken out, Germany did not supply the material, and the construction of the rigid airship had to be interrupted. Then England proposed to construct the " G." type rigid airship and an agreement was come to, but before starting the construction the former brought down a Zeppelin airship, and it was decided to take it as a model instead of the Italian airship. Three models of this construction have been exhibited at Olympia. It is interesting to note, in order to establish historical priority, that the form and position of the power cars and of the stabilising fins of the " G." type (1913-14) have since been adopted by Count Zeppelin.

So far I have spoken of the activities of Italian military aeronautics only in the lighter than air field, but, although this activity was very extensive, and its leader, Gen. Crocco, is best known for it, it must be understood that it did not exhaust all the energy of Italian military aeronautics. As regards Gen. Crocco, it is interesting to observe that he initiated his scientific career in 1904 with his well-known note to the " Académie des Sciences " on the " Stability of Airships " only by chance, as this note constituted only an exemplification of a very general problem which was at that time being studied by him : the problem

of a body free in space. Later, when he started in 1906, with his collaborator, Ricaldoni, the study of a military airship, it was only on the instructions of the War Ministry that he was compelled to interrupt his personal studies on aeroplanes which originated from the earliest days of his youth, when he was still a pupil of the Military Academy. In fact, in 1903 Crocco wrote an article on aeroplane theory, which remained in manuscript but which was made public by him in a lecture delivered early in 1904, showing a small streamlined cantilever monoplane without control surfaces and fitted with variable incidence wings for longitudinal and lateral stability (Fig. 7). Longitudinal stability was insured automatically by means of an elastic articulation, through which the wings assumed the necessary incidence, while by means of a manually-operated lever the wings were moved for the aeroplane to descend or ascend in the vertical plane.

FIG. 8.

80-100 *h.p. C.R. hydroplane on Lake Bracciano testing airscrew*, 1907.

Lateral stability was maintained manually by the pilot through the same lever, which, acting on the elastic articulation, moved the two wings oppositely. The same manœuvre made the monoplane turn.

For the first part of his monoplane automatic device—*i.e.*, for longitudinal stability—Gen. Crocco had taken out a patent in 1903. But it was the second part which was historically more important, as with it Crocco solved at least theoretically the problem of lateral stability independently and on the same principle as the brothers Wright.

Of this variable incidence wing monoplane a model has now been constructed from the original drawings and exhibited at Olympia.

Thus in 1903 the solution of aeroplane stability appeared possible in Italy; but the aeroplane itself appeared still a complicated machine. Its starting and landing, especially the former, presented for Crocco very absorbing problems. How to communicate to the aeroplane the necessary speed to sustain itself? And if this velocity had been obtained, how could it be maintained by the propeller?

Crocco and Ricaldoni read the patent of Forlanini on his hydroplane and thought that this machine would give the required means of solving the two problems. In the first place the hydroplane, according to the idea of Forlanini, could obtain, by gliding on the water, a high speed, permitting an examination

of the problem of transition from the water to the air, *i.e.*, from the hydroplane to the aeroplane; and, on the other hand, the hydroplane itself could provide the means of studying a suitable aerial screw.

A new hydroplane on Forlanini's principles was constructed by Crocco and Ricaldoni in 1906, and with this free hinge and variable incidence screws were studied, which were then applied to the military airships.

The Crocco-Ricaldoni hydroplane constituted thus the first experimental apparatus to test aerial propellers. The photograph (Fig. 8) represents it in motion on Lake Bracciano in 1907. The full-size machine was on view, during the Exhibition, at the Science Museum, South Kensington.

To the same subject of screws belongs a numerous series of aerodynamic researches, which were carried out before the war by Crocco, with his collaborator, Costanzi. Among researches specially worthy of mention are the experiments on lifting propellers and the helicopter.

It is known that one of the main problems of the helicopter is the descent with engine switched off. Now Crocco observed in 1906 the phenomenon of the self-rotation of propellers, and established that a self-rotating propeller, *i.e.*, one maintained in motion by the speed of the descent, was able to act as a parachute

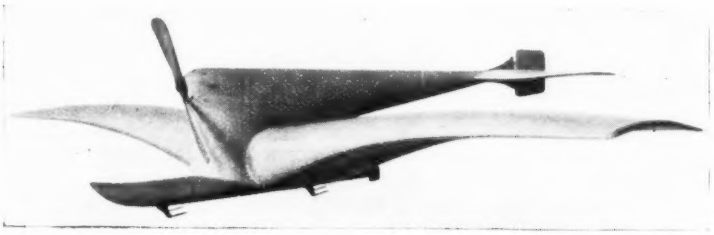


FIG. 9.
General Guidoni's low-wing monoplane boat, 1912.

whose virtual surface was similar to the disc of the propeller. Further researches of Eng. Costanzi proved in 1912 that the disc of the propeller was equivalent to double the parachute area, and recently Senor La Cierva told Crocco that, according to his own experiments, the virtual parachute is actually even greater in equivalent area.

A further observation on the same subject was made by Crocco, that for obtaining a velocity of descent compatible with safe landing a great diameter was necessary. In order to reduce this diameter Crocco contemplated having a high rate of descent and braking on nearing the ground by inverting the pitch of the propeller. For this a patent was taken out in 1906, which was later adopted by Mr. Pateras Pescara.

As regards practical flying in Italy, we do not find in its early days a series of gliding experiments as in other countries, except a few carried out by a naval officer, Lieut. Calderara, in 1902 by himself, and in 1905 with the assistance of Mr. Voisin, who had been called for this purpose to Italy.

In 1909 Wilbur Wright was invited to Italy and instructed the same Lieut. Calderara, who was the first Italian pilot, in the piloting of his machine.

With the arrival of Wilbur Wright in Italy our aviation began, and with it the first Italian construction, among which I will confine myself to the " Chimera " of Eng. Marchetti of 1910, and the Crocco-Ginocchio Canard flying boat of 1911, fitted with two lateral fins and small hydroplane wings. The same small hydroplane wings were fitted to another interesting project for that time—a cantilever streamlined monoplane designed by Gen. Guidoni (Fig. 9).

In 1913 the construction of this machine was begun, but was interrupted, and not again resumed. Later Gen. Guidoni gave it a more practical form, but this new version also was never realised, which Gen. Guidoni deplored to the end of his life.

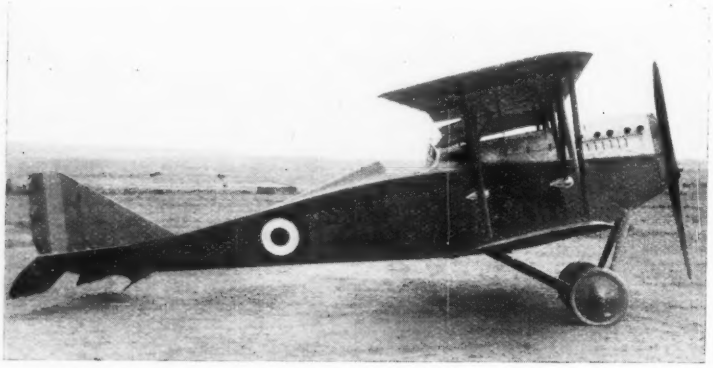


FIG. 10.

S.V.A. reconnaissance biplane, 1916.

Other land and sea experimental machines, among which in 1914 was a seaplane known as "Construzioni Aeronautiche," designed by Gen. Guidoni, were constructed at that time with some good features, but the war broke out, and foreign machines were adopted in the Italian Army and Navy. Machines

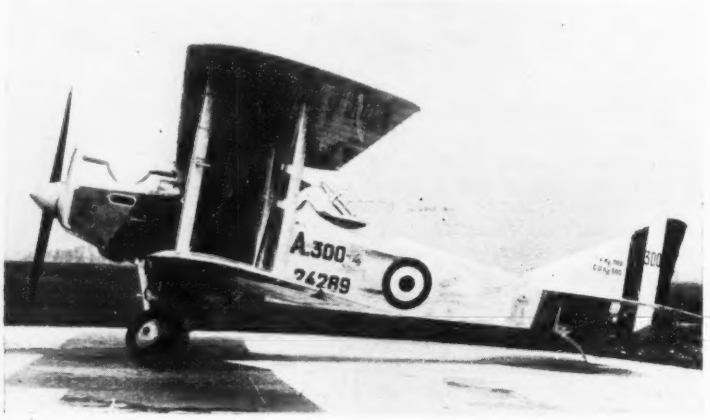


FIG. 11.

Fiat A.300 biplane with 400 h.p. A.20 engine.

of purely Italian origin, limiting myself to quoting only those constructed on a large scale during the Great War, were the following :—

Caproni Ca. 300 tri-motored biplane; S.V.A. biplane for reconnaissance and light bombing; M.5 pursuit seaplane; Ca. 300, which had a minimum speed

of 56 m.p.h., a maximum speed of 84 m.p.h., a ceiling of 13,400ft., and a useful load of 2,200 lbs.

The S.V.A., designed by Gen. Verduzio, Colonel Savoja and constructed by the Ansaldo firm, was of great importance in the history of air technique, having

FIG. 12.

Fiat A.22 reconnaissance monoplane—500 h.p. Fiat A.120 engine.

been the first machine, at least in Italy, in which aeronautical construction came out of the empirical stage to enter the well-established field of mechanical construction (Fig. 10). In other words, for the first time an aeroplane was studied in its entirety as well as in its details by the most modern methods of science.

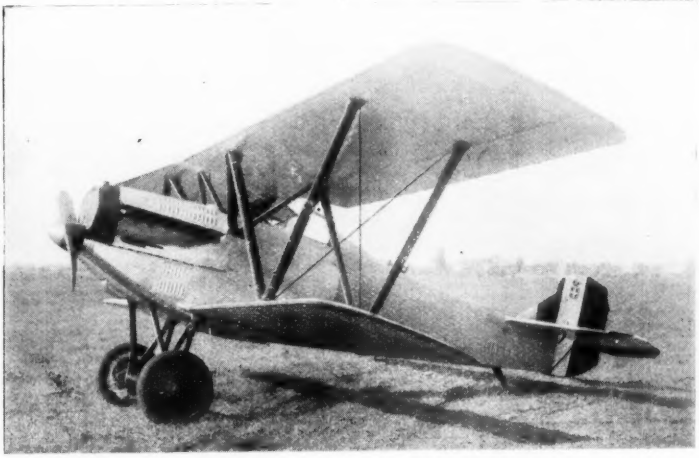


FIG. 13.

Fiat C.R.20 pursuit aeroplane with 400 h.p. Fiat A.20 engine.

In fact, all its characteristics, both structural and aerodynamic, were studied, and its performance calculated before it was actually constructed.

The project of the S.V.A. was begun in 1916 and the three first machines were ready in March, 1917.

At that time the maximum horizontal speed ranged from 94 to 100 m.p.h., the rate of climb was 20 minutes to reach 13,500ft., and the range was from 1½ to 2 hours. At the end of 1917 the following performances were attained :—

Maximum horizontal speed : 131 m.p.h.
Rate of climb : 20 min. to 16,700ft.
Endurance : 2½ hours.

FIG. 14.
Caproni Ca.73 bombing biplane.

The S.V.A., at the date of its flying tests, October 5th and 10th, 1917, showed, with an S.P.A. 200 h.p. engine, the following performance :—

Maximum horizontal speed : 143 m.p.h.
Rate of climb to 16,400ft. : 18 min. 15 secs.

FIG. 15.
Cant 22 passenger flying boat.

The M.5 must be considered as one of the best seaplanes of the war period, and was widely employed in the pursuit squadrons operating in the Adriatic. Performance : Maximum speed, 110 m.p.h. ; rate of climb, 28 mins. 30 secs. to 16,900ft. ; useful load 600 lbs.

From the M.5 with some improvements was derived, before the end of the war, the M.7, which reached 130 m.p.h. speed and carried 740 lbs. useful load.

Chapter IV.—From the End of the World War to the Present Day

The fatigue which followed our enormous efforts in the war is well known, and the difficulty Italian work, industry and general social and political life met in the immediate post-war years, until at the end of the 1922 year a man of strenuous will and force seized the rudder of the State and a new conception of national life was diffused in Italy. Industrial production and technical organisation of State aeronautics were restored. In this matter the name of General Guidoni, who organised industry and created the Aeronautical Engineer Corps, has to be mentioned. The Air Force and a military doctrine of aerial war was

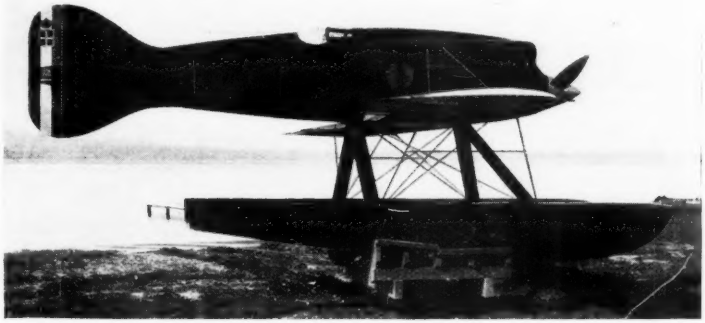


Fig. 16.

Macchi M. 39. Winner of the Schneider Trophy, 1926.

created, training assured, civil aviation established, advanced aeronautical schools founded, and a wide aerial propaganda diffused throughout the country. Such has been the work of the years in which Italian aeronautics has been by our Premier, Sig. Mussolini, entrusted to General Balbo.

Without entering the field of organisation and training, of the efficacy of which I believe that the three cruises carried out in West, North and in East Europe under the guidance of General Balbo are sufficient proof, I will only mention that we have been till quite recently holders of three world records. Speed (De Bernardi), duration (Ferrarin), distance (Ferrarin). I will give a rapid survey of the more important machines developed in this period, pointing out those which will remain in service at the end of 1930.

At that date the reconnaissance machines, Ansaldo A. 300-4 and Ansaldo A. 120, will be in service, together with the Romeo Ro. I.

The A. 300-4 was constructed in 1923; but its adoption in service has been subordinated to the substitution of the new Fiat A. 20 for the old 300 h.p. Fiat A. 12-engine (Fig. 11).

The A. 120 was constructed in 1926 and is equipped with the Fiat A. 22, 500 h.p. engine—minimum speed, 65 m.p.h.; maximum speed, 152 m.p.h.; ceiling, 22,000ft. (Fig. 12).

The Fiat CR. 20, constructed in 1926, will remain the Italian pursuit machine, the Ansaldo AC. 2, Ansaldo AC. 3, Fiat CR. 1 and Fiat CR. 2 being replaced by it.

The Fiat CR. 20 is equipped with the Fiat A. 20, 410 h.p. engine. Minimum speed, 52 m.p.h.; maximum speed, 172 m.p.h.; rate of climb, 18 mins. 55 secs. to 28,000ft. (Fig. 13).

For day bombing purposes we have the Fiat BR. 2, derived from the former BR. 1, constructed in 1922, but the modern Fiat A. 25 1,000 h.p. motor is being substituted for the old Fiat A. 14 motor. The designer of the Fiat aeroplanes is Eng. Rosatelli.

For night bombing the Caproni Ca. 73 is undergoing important alterations, which will make it more fitted for war purposes (Fig. 14).

Maritime aviation is represented by Macchi, Savoja, Fiat, Cant seaplanes, the latter only for civil purposes: Cant 22 is in service on the line Turin-Venice-Trieste-Zara-Venice (Fig. 15).

FIG. 17.

Macchi M.52. Set up speed record of 318 m.p.h., March, 1928.

Among the Macchi seaplanes we have to quote the famous racing machine, M. 39, winner of the Schneider Trophy in 1926, with its 246 m.p.h. (Fig. 16) and M. 52, with the Fiat AS. 2, 800 h.p. engine, which is the holder of the speed record with 320 m.p.h., made in March, 1928 (Fig. 17). The designer is Eng. M. Castoldi.

The Savoja machines are the creation of the well-known designer, Eng. Marchetti, and are shortly going to be manufactured in America, like some of the Caproni models. The Savoja S. 55 monoplane (min. speed 67 m.p.h., max. speed 122 m.p.h., ceiling 22,500ft.), fitted with two Asso 500 h.p. engines, is the bombing machine (Fig. 18) and Savoja S. 59 bis biplane, fitted with one Asso 500 h.p. engine, is the reconnaissance machine for Italian maritime aviation (Fig. 19); while for pursuit purposes the Fiat CR. 20 has been transformed into a seaplane, which has been exhibited at Olympia.

S. 55, which is also adopted for civil purposes, and as such is used on the line between Rome and Sardinia, was constructed in 1926. It was used by General De Pinedo in his Transatlantic flights, while his preceding flight of 34,375 miles across the Indian Ocean, Australia and Japan, was made with the S. 16 ter.

The S. 55, with its performances on the water and in the air and arrangement of airscrews, represents a machine which has not yet been surpassed by further improvements in technique. By merely transforming it from a seaplane

into a land machine and by diminishing the power, Eng. Marchetti derived from it the S. 64 aeroplane, with a performance which has not yet been reached by anyone else (Fig. 20). With this machine, Ferrarin and Del Prete brought to Italy the duration and distance records.

For these results we are indebted also to our engines, which are the products of two firms: Fiat and Isotta Fraschini. The first aviation engine of the latter belongs to 1908, while its new series Asso started in 1923. The most modern motors of both these two firms were exhibited at Olympia: Fiat A. 22, 500 h.p., Fiat A. 25, 500 h.p., Fiat A. 50, 100 h.p.; Asso Caccia, 450 h.p., Asso, 500 h.p., Asso 1,000 R.I., 1,200 h.p., with reduction gear, which is the most powerful engine exhibited at Olympia. At present very light engines weighing 0.770 lbs. per h.p. are under preparation by these firms for the Schneider Trophy competition.

The machines we have examined belong to a period which, of course, is already surpassed. It may be said that the production of to-day realises the results of the experiments of three years ago, while the results of to-day's experiments will not appear fully for another three years.

FIG. 18.

Savoja S.55 twin-fuselage bombing seaplane.

Besides the present extensive production of light planes and low power motors, which did not exist a few years ago, we must mention a noticeable tendency in Italy towards metal structures; steel, duralumin and mixed construction. Elektron is not used yet in aeroplanes, but only in engines. Another remarkable tendency in our technique is that towards great endurance and high speeds. Three big machines are at present under construction to this end at the Breda, Caproni and Fiat firms, which will be known as CC. 1,500 h.p. monoplane of duralumin, Caproni 3,000 h.p. monoplane of steel, and Fiat B.R.G. 1,500 h.p. monoplane of mixed construction, designed by Eng. Rosatelli.

The Breda C.C. monoplane, designed by General Crocco with the collaboration of General Costanzi, will have among various original features that of a single spar wing.

In conclusion I will deal briefly with scientific and experimental researches and aeronautical education. For the latter, two Aeronautical Engineering Schools are now open in Italy, at Turin and Rome, to which engineers are admitted and after a year's course are graduated Aeronautical Engineers.

As regards modern scientific researches, there are many names of scientists which one would like to mention, but I shall confine myself to the most prominent ones. My record shall begin with the well-known mathematician, Prof. T. Levi-Civita, University of Rome, for his studies on slipstream and wave motions and quite recently on the boundary layer; Prof. E. Pistolesi, University of Pisa, for his studies on airscrew theory, to the promotion of which he largely contributed; Prof. G. Albenga, University of Turin, on mechanics of flight; Prof. Cisotti, University of Milan, on classic hydrodynamics, and Prof. M. Panetti, for

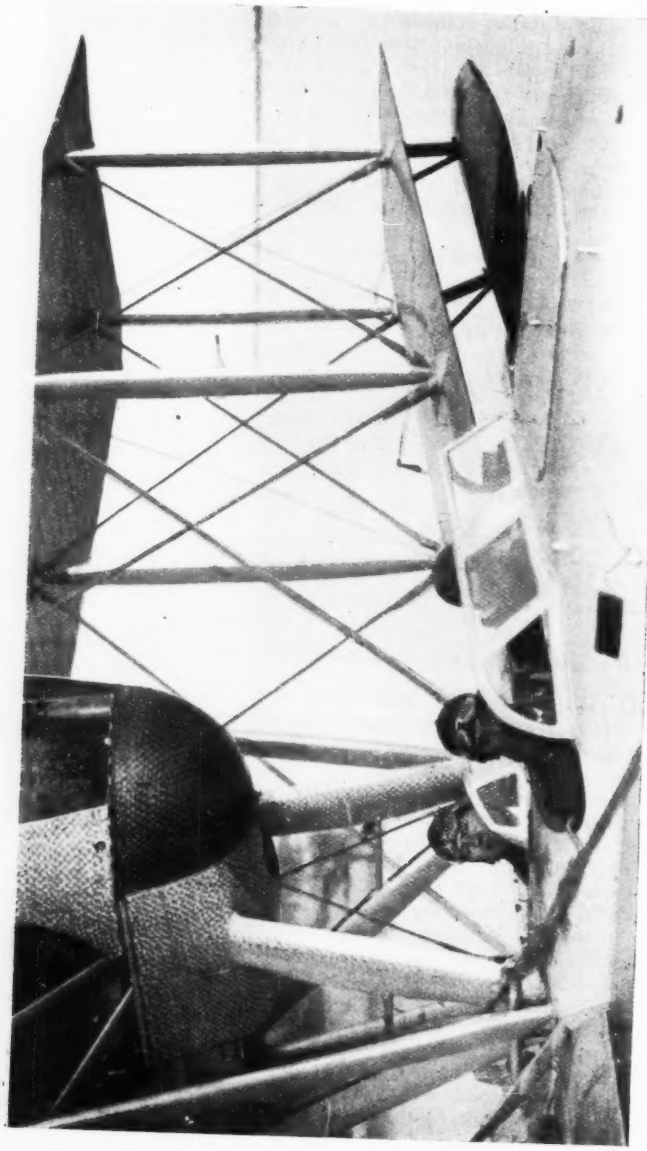


FIG. 19.
Signor Balbo, Under-Secretary of State for Aeronautics, piloting a Savoia S.59, with Signor Mussolini as passenger.

the various important researches carried out by himself and others in his aerodynamical laboratory in the University of Turin.

A branch of science connected with aeronautics, to which Italy is largely contributing, is aerial photogrammetry. The name of Prof. Cassinis, of the University of Pisa, must be recorded in connection with the scientific side of this work, while Signor U. Nistri is the inventor of a very successful photocartograph, exhibited at Olympia, for solving automatically the various problems involved.

But in addition to the physical side of aerial science there are also the biological and moral sides to be taken into consideration, namely, medical aviation and air legislation.

Air legislation courses have been held for some years in two Italian Universities, by two well-known jurists, viz., Prof. A. Giannini in the University of Rome, and Prof. P. Cogliolo in the University of Genoa; while an Aerial Law Institute was established two years ago at the Rome Aeronautical School and entrusted to Prof. A. Ambrosini.

Medical aviation started in Italy under very good auspices, following in the scientific tradition of Angelo Mosso's researches on mountain illness. Amongst the most important names in this connection are the late Prof. G. Gradenigo,

FIG. 20.

Savoja S.64—distance and duration record holder.

University of Naples, the late Prof. G. Galeotti, University of Bologna, Prof. A. Gemelli, Rector of the Catholic University in Milan, and Prof. A. Herlitska, of the University of Turin.

The methods of testing pilots used by Italian Medicine Aviation were shown clearly by a large 1/10th scale model, exhibited at Olympia, representing the scheme of the Psycho-Physiological Institute, which is to be built in Montecelio Experimental Field, near Rome.

We must finally not forget that, in connection with all branches of aeronautical science, the Associazione Italiana d'Aerotecnica has carried out a very useful work of co-ordination amongst all those interested in aeronautics. Our Society was founded in 1920 by General M. Moris, who played for many years a very important part in the development of Italian aeronautics.

Before closing my survey I have to call your attention to two facts which have seriously handicapped the development of our scientific researches in respect to other countries. On the one hand our language is very little used abroad and therefore our scientific publications cannot be known as they deserve, nor become the subject of discussions by foreign scientists. In order to eliminate, or at least to reduce this drawback, our Society has taken up from the beginning of the year the system of publishing in the "Aerotecnica," our monthly magazine, a short résumé in English of the various articles contained therein.

On the other hand, Government organisation has not yet been able to provide fully and completely for the scientific side of aeronautics, as it has done for all other more urgent needs, that is to say, for service, training, civil aviation, and for construction. In fact, the strenuous work which in these last years has been carried out for restoring Italian aeronautics has left out, on account of the limited resources of our air estimates, the experimental equipment. So we, who in the years before the war, had aerodynamical laboratories which were a model to foreign establishments, are at present seriously handicapped in all experimental work and researches, lacking in adequate means. But it is hoped that this condition will cease before long, as efforts are now being made for providing our Government establishments with up-to-date experimental equipment and with a sufficient staff for carrying out the experimental researches involved.

THE DEVELOPMENT OF AVIATION AND AERONAUTICAL RESEARCH IN HOLLAND IN RECENT YEARS

BY

DR. IR H. J. VAN DER MAAS

(*A Paper read before the Society at Olympia, July 26th*, 1929.)

To understand aviation in Holland well, it is necessary to draw special attention to two points. The first is that Holland is a small country with a small military force and industry; both are also relatively small. The second point is that Holland has always occupied a central position in traffic lines. These two leading factors also rule things in aviation. They explain the following:

The industry exists without any financial aid from the Government and only a small number of military machines are required annually. The air-traffic company (K.L.M.—Royal Dutch Air Lines) has a small amount of Government subsidy, but has, however, the advantage that the interest of our bankers and shipping concerns, in a quite natural way, is directed towards traffic in general and this interest could be won for air traffic in particular. The Government is fully alive to the importance of this new branch of transport.

When we now turn to history the following can be seen.

Industry

Foreign machines were used in Holland at the outbreak of the war (type Farman). In the beginning of the war some machines were built by the Spyker Works, which later on developed the Spyker types V.1 and V.3 in which Gnôme et Rhône and Thulin engines were mounted. In 1927 the v. Berkel Works started building float-seaplanes W.A. and W.B.

As no research data of other countries could be obtained in 1918 the Ryks-Studiedienst voor de Luchtvaart (National Institute for Aeronautical Research), was founded by the Government; Dr. ir. E. B. Wolff was appointed as its Director and still retains that position.

After the end of the war Fokker and Koolhoven returned to Holland and began to build; the first founded his own works immediately, the second first in the Spyker Works, later on (1922) in the Nationale Vliegtuig Industrie and now under his own name.

Another aircraft constructor, Mr. Carley, had built machines during the war and still does so.

The Fokker Works produced several types of military machines and developed a series of commercial aeroplanes, called: F.II, F.III, etc., as far as F.XIV. The F.VII with one and three engines is one of the best known all over the world. Licences for military and commercial aeroplanes have been sold to more than 10 countries.

Mr. Koolhoven also built military and civil machines. Among the latest the 3-engined FK.33 should be mentioned. Mr. Koolhoven is at present building light planes, type FK.41, the licence of which has been sold. (Desoutter).

Spyker and v. Berkel no longer built during the depression following the war and it was not until 1924 that Pander began to build light planes and 1927 that "Aviolanda" produced boats of the Dornier Wal type for the Navy in the Dutch East Indies.

Traffic

In 1919 the E.L.T.A. (First Aero Exhibition, Amsterdam) was organised. General Snyders and Mr. Plesman were the moving spirits. By this exhibition aviation gained much more interest in Holland, and immediately after, the K.L.M. was founded by the same persons together with some bankers and shipping-concerns. Mr. Plesman was and is still the K.L.M. leader.

This society started flying on the 18th of May, 1920, the first line being Amsterdam-London. From the beginning the intention was, on this first line and other short ones, which followed afterwards, to gather experience for the future flying service Amsterdam-Batavia v.v. It goes without saying that several short lines soon proved their value.

From the beginning the organisers tried to build up the K.L.M. on a sound financial basis and to make it a commercial self-supporting enterprise.

Table 1 shows what has been done in that direction.

TABLE 1.

Year.	Number of Ton/km. Offered.	Price per Ton/km.
1922	163,000	fl. 4,74
1923	239,000	fl. 3,00
1924	359,000	fl. 2,23
1925	610,000	fl. 1,80
1926	883,000	fl. 1,41
1927	1,272,000	fl. 1,21
1928	1,760,720	fl. 1,17

The large trial flights Amsterdam-Batavia were carried out with commercial aeroplanes under the patronage of the Comité Holland-Indië, whose president is General Snyders. The first one in 1924 was performed with an F.VII Rolls Royce machine and was also the first long-distance flight with a commercial aeroplane; in 1927 two return flights were made, the second one of which was undertaken to establish a postal service between Netherland and its East Indies; in 1928 four machines flew to Batavia and two return flights were performed to show the possibility of a weekly postal service between the two parts of the Kingdom. In this connection the pioneer work done by the pilots, v.d. Hoop with v. Weerden Poelman (1924) and later on by Geysendorffer and Scholte (1927), Koppen and Fryns (1927) should not be forgotten; nor the fact that Mr. v. Lear Black was the passenger in one case (1927) and that he chose for his longer trips K.L.M. organisation and Fokker machines. It is hoped that in the beginning of 1930 the line Amsterdam-Batavia can be flown with as great a regularity as the other lines; the regularity is now 96.1 per cent.

Table 2 demonstrates the development of K.L.M. traffic.

The Fokker machines used are for the greater part of the types F.VIIa Jupiter, F.VIII twin-engine Jupiter, F.VIIb three-engine Titan.

For the maintenance of the flying service in the Dutch East Indies itself a special company was formed, called the K.N.I.L.M. (Royal Dutch Indian Airways). The first lines Batavia-Bandoeng and Batavia-Semarang were opened on the first of November, 1928. The aeroplanes used are Fokker F.VII three-engine Lynx machines. During the first half year in 1,227 hours 191,957 km. were flown and 6,002 passengers, 67,000 kg. luggage, 10,424 kg. goods and 695 kg. mail were carried. The regularity was 99.76 per cent.

For the British Empire the connecting link between its Indian Colonies and Australia will probably pass Dutch East India. Then a collaboration between the British air lines, K.L.M. and K.N.I.L.M., may be expected.

TABLE 2.

	1920	1921	1922	1923	1924
Kilometres ...	82,000	350,000	397,000	540,000	790,000
Passengers ...	345	1,664	1,414	3,937	3,648
Goods (Kgs) ...	22,000	44,000	90,000	166,500	147,000
Letter Mail (Kgs) ...	2,900	1,500	1,000	1,700	1,650
Parcel Mail (Kgs) ...	—	—	2,700	7,300	10,500
Persons (joy-rides) ...	—	150	2,300	2,000	2,550
Percentage of costs made good by the revenues ...	—	33·7	27·2	34·3	47·6

	1925	1926	1927	1928
Kilometres ...	965,000	895,000	1,310,000	1,623,060
Passengers ...	5,729	6,275	12,916	17,007
Goods (Kgs) ...	225,000	255,000	402,000	674,000
Letter Mail (Kgs.) ...	2,100	2,400	19,900	34,862
Parcel Mail (Kgs) ...	9,800	6,000	16,500	23,237
Persons (joy-rides) ...	6,900	2,500	16,000	17,200
Percentage of costs made good by the revenues ...	56	59	69.3	70.1

Sport

We possess the Aero Club as the Dutch link of the Fédération Aéronautique Internationale.

Only one flying club (R.A.C., Rotterdamsche Aero Club) exists up to the present. It was founded in 1927. It yearly organises competitions, in which many foreign light planes take part.

This R.A.C. has founded a National Flying School and instructs the pupils of this school in flying. The military forces provide K.L.M. with pilots, the R.A.C. only produces private aviators.

Research

The R.S.L. (Ryks-Studiedienst voor de Luchtvaart) mentioned above, was founded in 1918. At first its task was limited to research, but soon afterwards when civil machines were built, the Government's task of supervising design, construction and flying qualities, was delegated to the R.S.L. So the combined work of the Royal Aircraft Establishment and of the A.I.D. is done in Holland by the R.S.L., though on a much smaller scale.

With regard to research work; it will be clear that in our small country it is necessary to leave the more expensive experiments to larger countries and the principal task is to assist the practical aeronautical engineer as much and as quickly as possible; so tests of practical value were undertaken. That does not mean that pure scientific work is neglected in Holland: Professor Burgers, of Delft Technical University, has, for example, experimented and developed the theory of the boundary layer.

Some investigations of the R.S.L. may be mentioned.*

Report A.14 (Part I.).—"Preliminary experiments on the effect of the method of suspension of the model in aerodynamic measurements on the results."

The disturbing influence of the parts fixing the model to the balance is very large. Great care should be taken to reduce this influence. In one case a difference of 40 per cent. in drag and 40 per cent. to 12 per cent. in lift was found.

Report M.40 A (Part I.).—"Tests on the strength of fuselages, composed of seamless steel pipes, jointed by autogenous welding."

The tests have been done with a view of forming an idea of the reliability of these structures. As Mr. Fokker built and still builds the fuselages of his machines of welded steel it was necessary to know the behaviour of the tubes

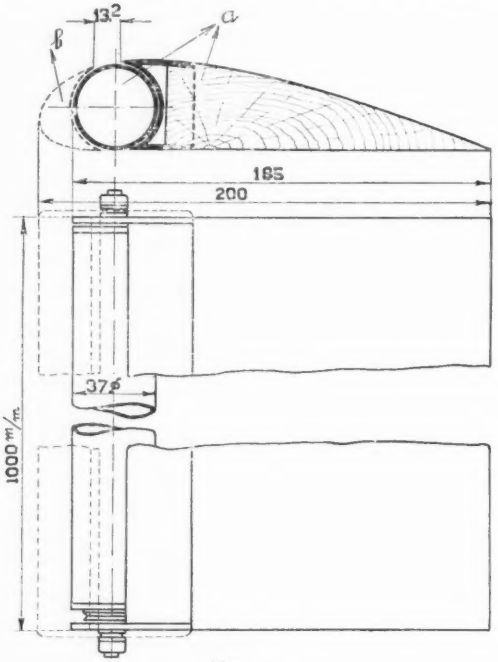


FIG. 1.

a. Model without nosepiece.

b. Model with nosepiece.

when in tension or compression, and under fatigue. It was found that inspection of a cut through a joint always shows little defects. They have no appreciable influence on the strength when they are not great in extent and the crystallisation of the two parts that meet in the joint is continuous. The elastic limit of the parts of the tube next to the joint is lowered by the heat of the flame; the deformation begins here. Practically all joints have been studied throughout a Fokker fuselage.

Against the results found in many countries the conviction was formed that welding was a trustworthy method of construction. In many years of practice this opinion has been borne out.

* These reports can be found in "Verslagen en Verhandelingen van den Ryks-Studiedienst voor de Luchtvaart, Amsterdam," Parts I., II., III., IV. and V.

These experiments have been of great importance, as now the greater part of our machines are of the welded fuselage type; they behave very well and it is the case that in accidents the personal damage is less than with wooden fuselages.

Report A.48 (Part II.).—"Unstable oscillations of a wing-aileron system."

This investigation was started by ir. A. G. von Baumhauer en ir. C. Koning, when unstable oscillations of a semi-cantilever monoplane were observed. No such phenomena of other machines were studied at that moment.

A model of the wing was tested in the wind-channel, where the fluttering could be copied. The weight of the auxiliary balancing surface could be modified. Theoretical considerations showed that the wing-aileron system could be made stable by reducing the distance of the centre of gravity of the aileron behind its axis. Theoretical and experimental results agree.

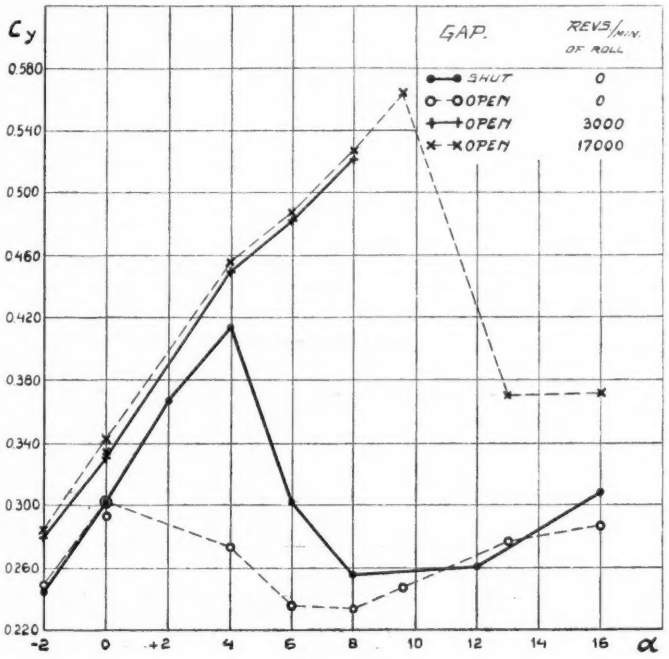


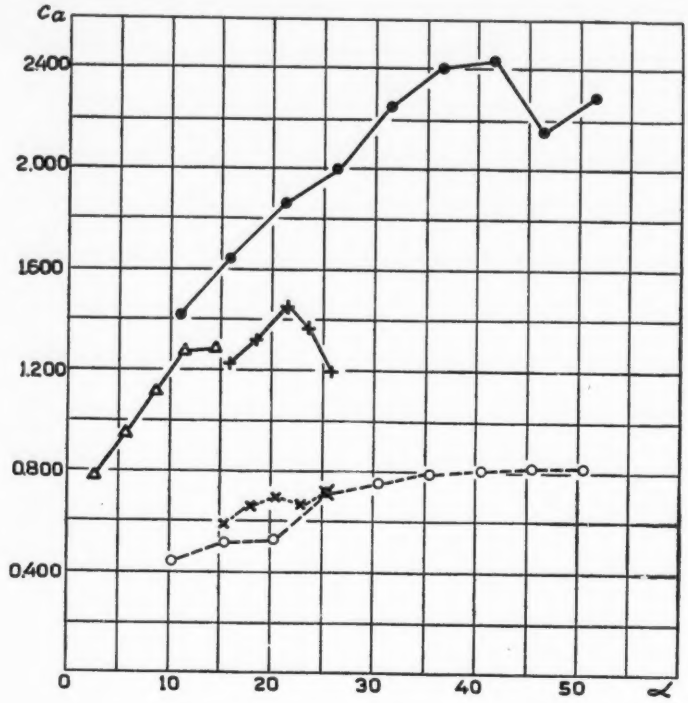
FIG. 2.

It is not necessary to go into further details as the investigation has been published at the Air Congress, London, 1923. A year later other laboratories in England, Germany, etc., took the subject in hand and investigated it thoroughly.

Report A.96 (Part III.).—"Preliminary investigation into the influence of a rotating cylinder in a wing section," by Dr. ir. E. B. Wolff.

From the results of other experiments it was already known that the forces acting on a cylinder are influenced by rotating it round its axis. It was the purpose to find out whether the forces acting on a wing model with such a cylinder placed in it could be altered also. If good results, as increase of maximum lift-coefficient were found, a practical application might be suggested.

Fig. 1 shows the model, Fig. 2 the results. This last one gives the lift-coefficients c_y plotted against the angle of incidence α. When the cylinder



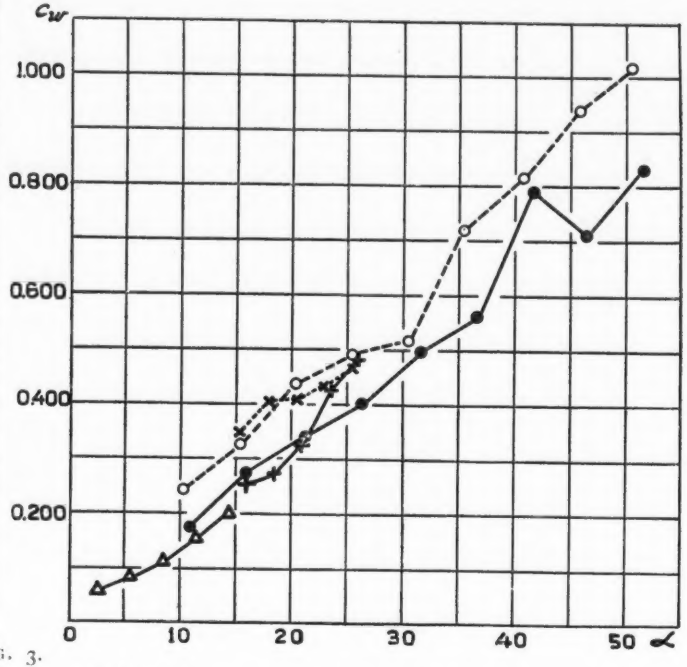


FIG. 3.

● *Model without nosepiece. Revolving roll.* + *Model with nosepiece. Revolving roll.*
○ ,, ,, ,, *Roll stands still.* × ,, ,, ,, *Roll stands still.*
△ *Model Göttingen 386.*

is at rest, the value of the maximum lift-coefficient is very low. This value was enlarged by filling up the gap between cylinder and sharp edge at the top of the wing. At some 10 per cent. below the original critical angle, the lift-coefficient increased, with the cylinder rotating with 3,000 or 1,700 revs. per min., whereas this angle itself increased considerably, accompanied by a greater value of the maximum lift-coefficient.

*Report A.*105 (Part IV.) gives "Further experiments on the influence of a rotating cylinder accommodated in a wing section," by Dr. ir. E. B. Wolff and ir. C. Koning.

As Fig. 1 showed, a nosepiece could be fitted. The influence of this piece

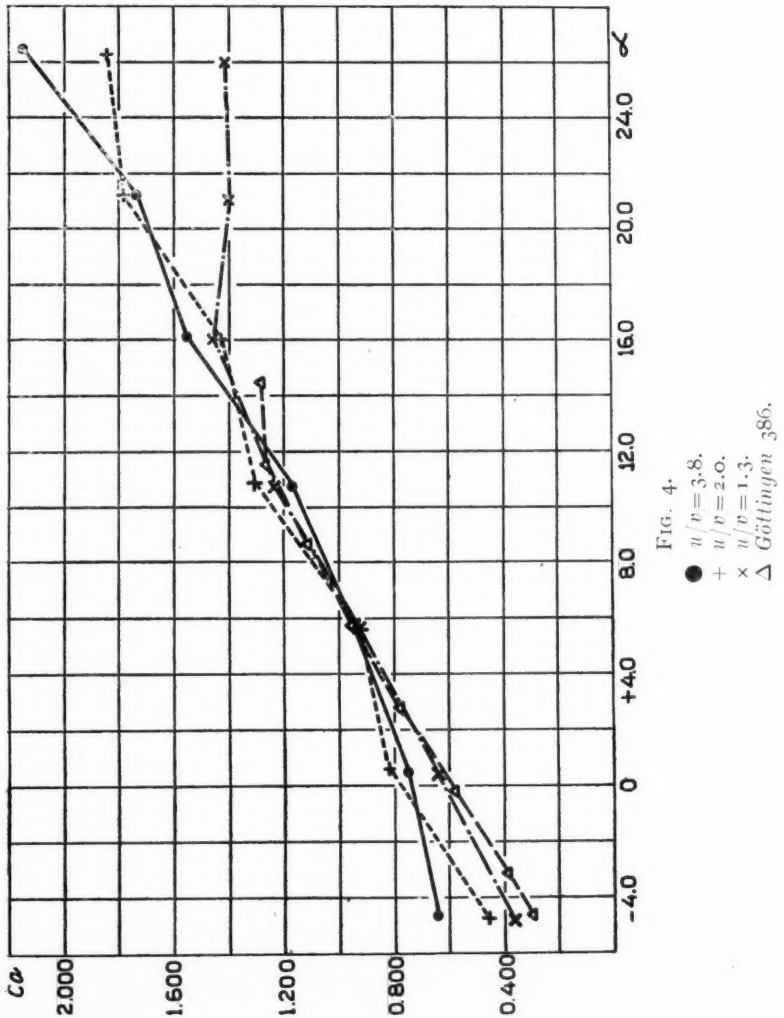


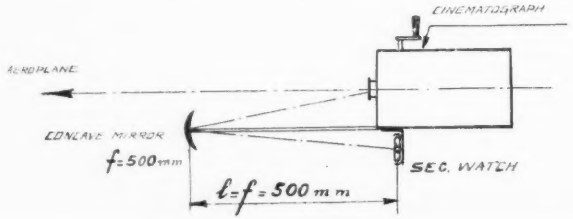
FIG. 4.
● $u/v = 3.8$.
\+ $u/v = 2.0$.
× $u/v = 1.3$.
△ *Göttingen* 386.

on the ratio of the circumferential speed of the cylinder to that of the wind (u/v) and the gap between cylinder and backpiece was investigated.

Fig. 3 shows the influence of the nosepiece, Fig. 4 how c_y changes with α for different values of u/v. It is clear now how the air flow is.

Report V.79 (Part III.).—"Photographic time studies of aeroplanes' paths," by ir. A. G. v. Baumhauer.

When the focus of the objective of a photographic apparatus is known it is possible to learn the distance of the photographed object from the camera



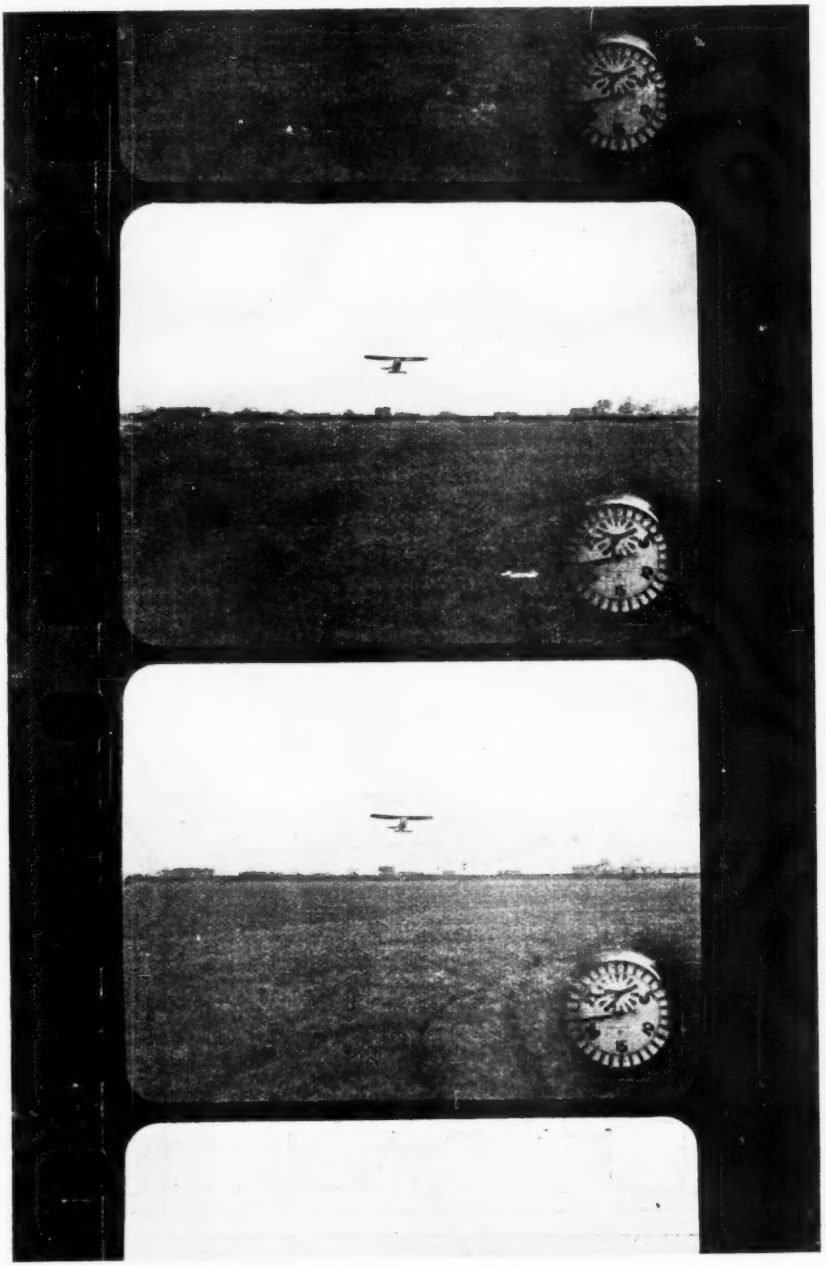


FIG. 5.

when one dimension of the object is known, *e.g.*, the span of the wing of an aeroplane.

If a watch is photographed too, and several photographs are taken or a cinematograph is used, data as starting—and landing—run, climbing, minimum and landing speed, can be determined, which are often difficult to measure, especially in the case of seaplanes. Fig. 5 shows the plan view and photo of the camera; also a specimen of a piece of film can be seen. The errors may be 8 metres when the distance of the object is 500 metres and f = 50 mm. When f = 720 mm., in the case of a distance 1,500 metres, the error may be 1/3 per cent.

We can mention also:—

*Report V.*175 (Part IV.).—" The influence of the ribs on the strength of the main plane spars," by Prof. ir. C. B. Biezeno, ir. J. J. Koch and ir. C. Koning.

This report is an example of the collaboration between Delft University and R.S.L. This investigation is carried on also with experiments.

*Report A.*32.—" Experiments on the action of the ailerons of a thick tapered wing," by ir. C. Koning and ir. H. J. v. d. Maas.

Some attention may perhaps be given to the experiments on longitudinal stability.

*Report V.*325 (Part V.).—" Elevator curves: their determination by means of flying tests and their significance for the judgment of the stability," by Dr. ir. H. J. v. d. Maas.

Up to the present the stability of an aeroplane is largely left to the judgment of the pilot, who may have a great experience but is unable to give data perfectly comparable with those of other flights. It was found necessary, therefore, to evolve a method which might tell something about longitudinal stability. A very simple method has been developed which makes it possible to construct the so-called " elevator curves " after flight tests of say 1½ hours with an experienced pilot and observer. Such a curve gives the relation between the position of the control stick (*i.e.*, of the elevator) and flying speed for one definite position of the engine throttle. So, with constant throttle, the control stick position necessary for equilibrium is observed at a given speed. The speed can then be varied and with it the stationary flying position. When enough

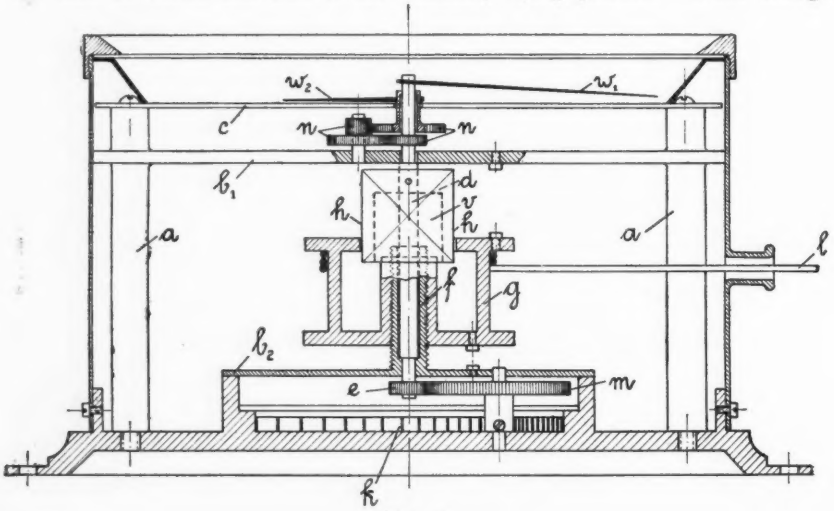


FIG. 6.

points have been taken, the throttle position can be altered and again the relation between speed and control stick position is noticed for a series of speeds. In several cases simultaneous readings were made of the engine speed (n) and the inclination of the machine.

The position of the stick can be seen on an instrument (Fig. 6) fitted on the dashboard; at normal elevator gearing the error is not more than 0.2°.

Now the value of these elevator curves is expressed by the fact that it can be proved that the slope of the curve which gives the relation between elevator angle β and angle of incidence α decides the longitudinal stability. It has been proved by Prof. Burgers (Chap. VI., Part V.), that when c_m is the moment coefficient and s indicates the position of the engine throttle, that the quotient $(\delta c_m/\delta \alpha)_{s=\text{const.}}$ forms this criterion.

c_m can be divided into a part $c_m{}^*$ which is determined for one definite position of the elevator as a function of the variables α and λ ($\lambda = v/nD$, when D = diameter of airscrew) and a part which depends upon the position of the elevator β. This resolution is expressed by the formulæ

$$c_m = c_m{}^* + m\beta.$$

m is a function of α and λ and is always positive. m can be determined by the above experiments if they are flown with different positions of the centre of gravity; another coefficient k is used more, which differs from m by a constant.

The coefficient k was determined for different aeroplanes, mostly monoplanes. The value of k as a function of λ is shown in Fig. 7.

Then it is possible to find c_m and the derivatives $\partial c_m/\partial \alpha$, $\partial c_m/\partial \lambda$ and $(\delta c_m/\delta \alpha)_{s=\text{const.}}$ When β and m are known in every flying position. The influence of the position of the line of action of the airscrew in height relatively

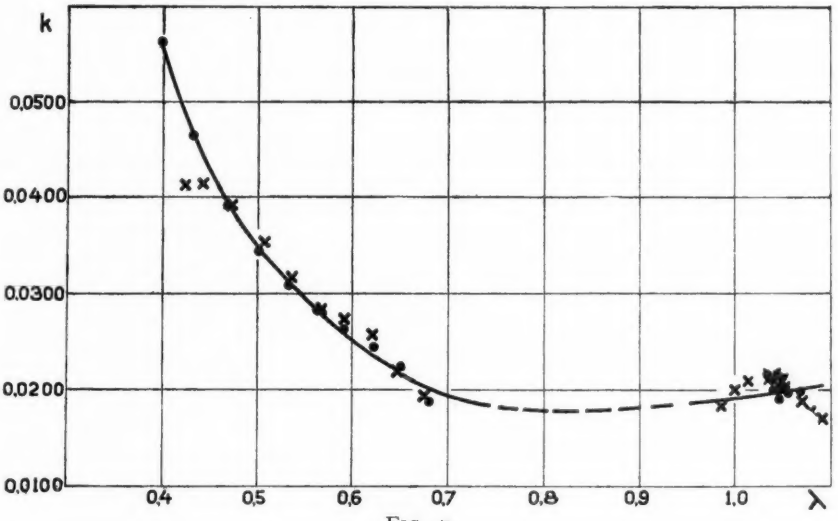
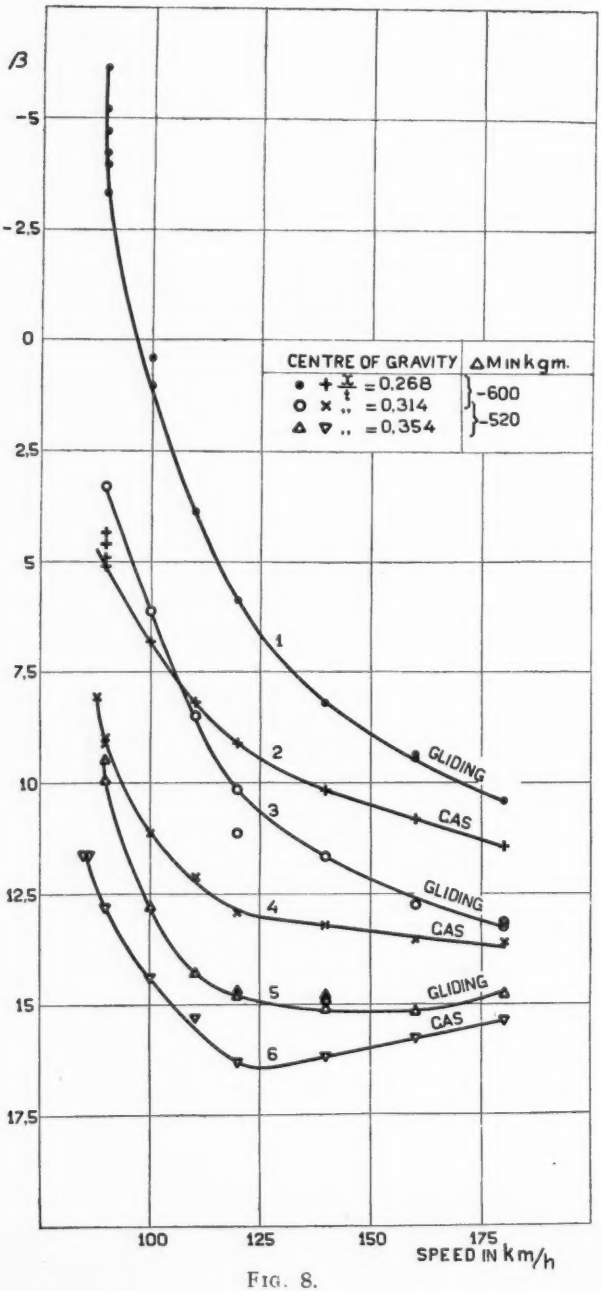


FIG. 7.

Aeroplane Type F.VII.a, three engines.

$k = (Ft/fl)\, m$.
F = *wing area.*
t = *wing chord.*
f = *tailplane surface.*
l = *distance of elevator hinges to centre of gravity of aeroplane.*


β
-5
-2,5
0
2,5
5
7,5
10
12,5
15
17,5
100
125
150
175
SPEED IN km/h
CENTRE OF GRAVITY
ΔM in kgm.
• + x/t = 0,268
o × ,, = 0,314
Δ ▽ ,, = 0,354
-600
-520
1
2
3
4
5
6
GLIDING
CAS
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CAS

FIG. 8.

to the centre of gravity of the plane cannot be neglected. This is in agreement with theoretical considerations. Specimens of elevator curves are given by the Figs. 8, 9, 10. Fig. 8 shows the influence of the displacement of the centre of gravity, Fig. 9 of the position of the gas throttle. In Fig. 10 we find the influence of the position of the engine in the vertical plane.

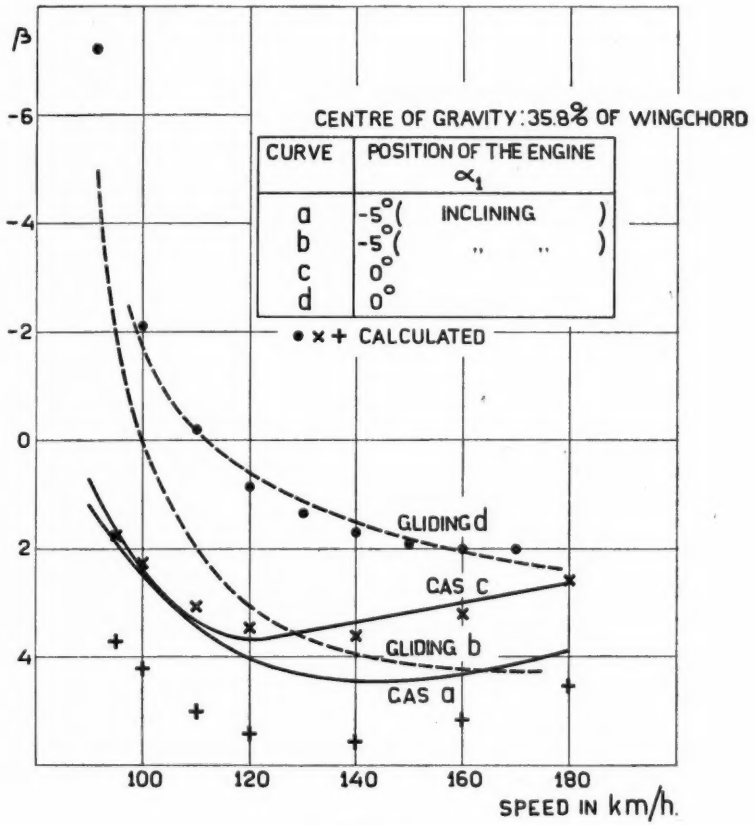


FIG. 9.

The significance of irregularities in the " elevator curves " has been studied. Also the influence of changes in the length of the fuselage and of the area of the horizontal tailplanes.

As mentioned above, it appeared necessary that $(\delta c_m/\delta\alpha)_{s=\text{const.}}$ should be positive in order that small oscillations about the stationary motion might be damped; if $(\delta c_m/\delta\alpha)_{s=\text{const.}} < 0$ the aeroplane aperiodically departs from the position of equilibrium.

From the relation

$$(\delta c_m/\delta\alpha)_{s=\text{const.}} = \partial c_m/\partial\alpha + (\partial c_m/\partial\lambda)\,(\delta\lambda/\delta\alpha)_{s=\text{const.}}$$

it appears necessary, with regard to gliding flight (where the influence of λ, that is the second term in the equation, may be neglected), that also

$$\partial c_m/\partial\alpha > 0.$$

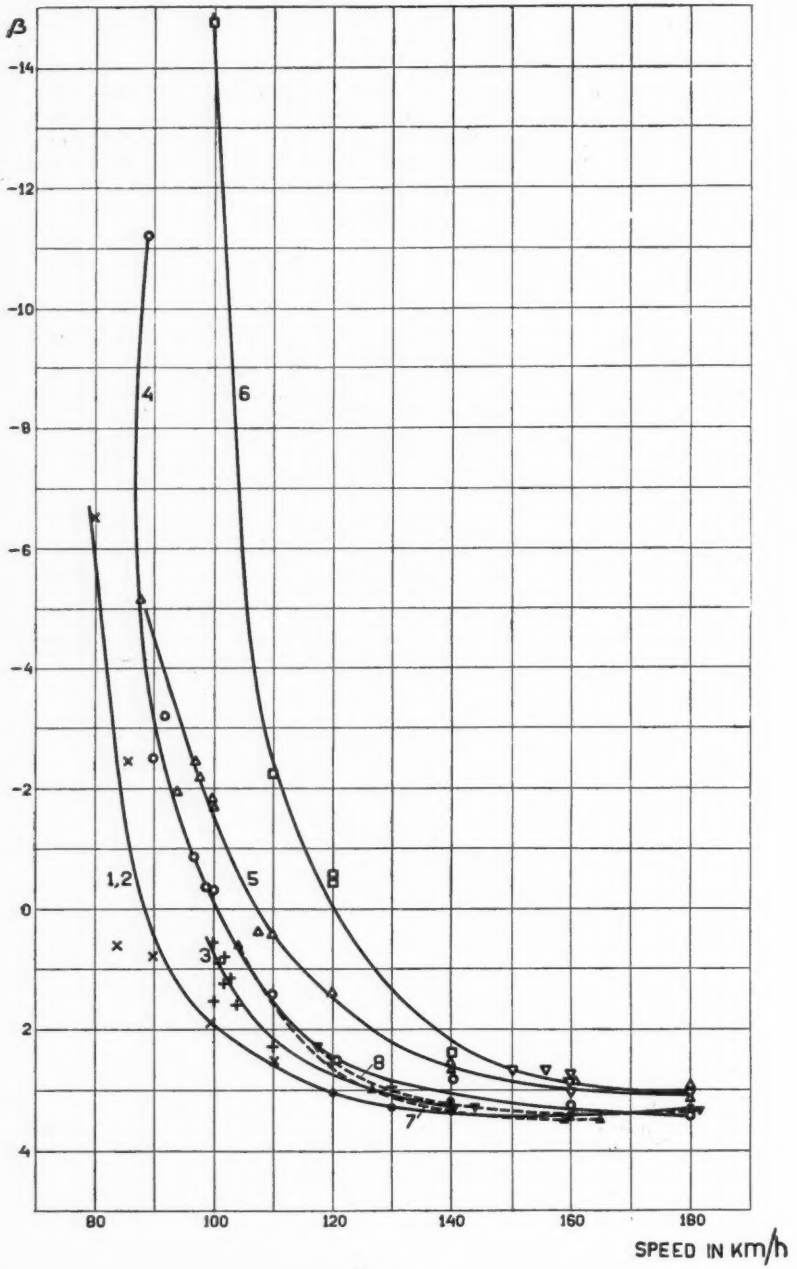


FIG. 10.

Aeroplane Type F.VII.a.
Centre of gravity: 34.7 per cent. of wing chord.
Curves 1-6 are curves of constant position of engine throttle.
Curves 7 and 8 are curves of constant λ.

The significance which in the literature on the subject is given to $\partial c_m/\partial\alpha$ is in agreement with this result (so-called "static stability"). Moreover, however, the factor $\partial c_m/\partial\lambda$ showed to be of certain importance; in the equation given above $\delta\lambda/\delta\alpha < 0$, hence if $\partial c_m/\partial\lambda < 0$, there is a favourable influence on the magnitude of $(\delta c_m/\delta\alpha)_{s=\text{const.}}$

The conceptions "stability of control" and "stabilising action of the engine" are introduced. An aeroplane possesses stability of control when $(\delta c_m/\delta\alpha)_{s=\text{const.}} > 0$, the engine acts stabilising when $\partial c_m/\partial\lambda < 0$.

Some importance must be attached to the consideration that an aeroplane for which $\partial c_m/\partial\lambda < 0$ has the tendency to slow down, when flying with fixed elevator the throttle is being closed; in certain circumstances this tendency may be dangerous.

An aeroplane for which $\partial c_m/\partial\lambda > 0$ will take up speed in the same case and will give a greater safety. In any case, however, it is of importance that $(\delta c_m/\delta\alpha)_{s=\text{const.}} > 0$.

The method of measuring is simple, apart from general difficulties which are inherent to flying tests. It quickly gives the data which are suitable for the practical judgment of the aeroplane under consideration and for its comparison with other types. Especially for the examination of a type-aeroplane it may render good services, because in this case unexpected divergences often present themselves. It is necessary to investigate the cause of these divergences, before it will be possible to find out their character and eventually improve the type; for this purpose the results of earlier systematic tests may be of great use.

I have tried to give an idea about the development of aviation in Holland.

The final conclusion must be that, notwithstanding difficulties, aviation in Holland grows; that its industry, though small, can compete with the best products on the market, that air traffic promises much and that research has found several points of prominent interest.

THE SOCIETY'S EXHIBIT

AT THE

INTERNATIONAL AERO EXHIBITION, OLYMPIA,

JULY 16TH—27TH, 1929

A SUMMARY

BY

THE EDITOR

The days July 16th—July 27th, 1929, were important days in the history of the Royal Aeronautical Society, with which is incorporated the Institution of Aeronautical Engineers. Never before has there been gathered together such a remarkable selection of historical material giving so complete and continuous a record of man's attempt to fly in Great Britain from the earliest legendary days to the year 1914. The period covered is the amazing one of nearly three thousand years, for the first reference is to King Bladud, 850 B.C.

The Historical Exhibit was prepared under the direct supervision of Mr. J. E. Hodgson, the Honorary Librarian, while the success of the organisation of the Society's effort as a whole was largely due to the unceasing energy of the President, Colonel the Master of Sempill. The unfailing enthusiasm of Mr. Hodgson, his ungrudging labour, and his complete generosity in lending without stint to the Society so many of the rare and unique examples from his own collection, undoubtedly made the historical section not only the best of its kind which has ever been shown, but added greatly to the prestige of the Society. In the list of individual exhibits which appear in the following pages the acknowledgments to Mr. Hodgson are alone sufficient to reveal how much and how freely he gave to help the Society, and the Council wish to place on public record, as they have already done privately, the deep sense of gratitude under which they will always remain to the Honorary Librarian for the enthusiasm he has brought to bear in furthering the advancement of the Society.

Behind the ultimate result which is revealed in the photographs of the Society's exhibits is hidden months of organising work, all steadily aimed at making both the exhibits of the Society itself and those shown under the ægis of the Society, as representative and complete as possible. The Society were fortunate in having at their service the organising ability of Colonel the Master of Sempill. From the time that it was decided how great a part the Society should play in the Exhibition, the President bent all his energies towards making that part international and welding the various sections of the exhibit into a homogeneous whole. His organising genius had free play and the result, undoubtedly, has been to raise the prestige of the Society to a still higher plane and to impress all those who visited the Exhibition with the work which the Society is doing.

In this connection it is worthy of mention that Mr. Rudyard Kipling, in acknowledging to the Honorary Librarian the return of the unique copy of "Actions and Reactions" which Air Commodore Maitland took across the Atlantic and back in R.34, referred in appreciative terms to the value of the Society's exhibit and expressed himself as proud to have been associated in this effort to stimulate the imagination of the public in such "vital" matters.

There are many others who willingly came forward to help by lending relics, MSS., engravings, photographs, books, etc., and every effort has been made to acknowledge their contribution to the greatest aeronautical historical

General view of gallery and cases.

exhibit ever shown. Special thanks are due to those members of Council who helped during the Exhibition—to Mr. Howard-Flanders, whose knowledge of the "Old Flying Days" was freely given every day to the many who came to study the photographs under his charge; to Mr. Dolby, who helped with the staff work, and to Mr. Balston for the success he made of the Model Aeronautical Engineers' Stand.

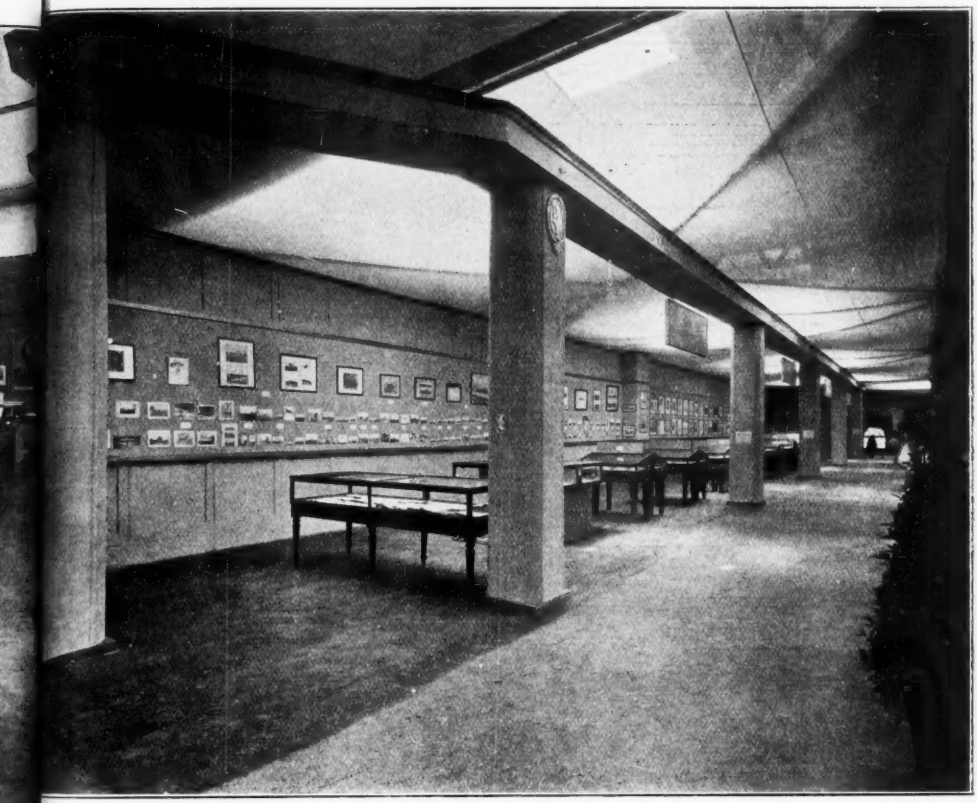
The Council owe a special debt of gratitude to M. Charles Dollfus, who was in charge of and arranged the French Section of the Society's exhibit; Professor Giacomelli and General Bartolucci for the arranging of the Italian Section; and Herr Langer for the arranging of the German Section.

The actual staging and decoration of the various stands were in the hands of the Department of Overseas Trade. Mr. Claude Taylor and Mr. Pratt drew on their experience of exhibitions, and willingly placed their knowledge and services at the disposal of the Society. To their names must be added that of Major O. G. G. Villiers, D.S.O., of the Air Ministry, who once more laid the Society under a deep debt of gratitude by the help he gave. Finally, thanks are due to the Exhibition authorities themselves, and to Mr. Phillips, the Exhibition Manager, in particular, for the constant help they gave in smoothing out difficulties which at times appeared almost insuperable.

View showing Cayley cases in foreground and framed engravings on panelled walls.

There is an aspect of the Society's exhibit which has not yet been touched upon, and that is the financial one. It was early realised that in order to participate in the Exhibition in a manner worthy of the dignity of the Society it would be necessary to spend a sum which would severely tax the Society's finances. After a thorough discussion of the schemes of participation which had been put forward, and a lengthy investigation of the probable costs and results which would be obtained, the Finance Committee recommended that a sum of £800 should be spent. The position was further discussed in Council, which agreed to adopt the report of the Finance Committee. At that Council

Meeting Captain Acland was present, and afterwards, through his services as Chairman of the Society of British Aircraft Constructors, the Exhibition Committee agreed to allocate a sum of £500 towards the cost of the Society's exhibit. The generosity of the Exhibition Committee did not end there, for they agreed to put over 8,000 square feet of valuable space at the disposal of the Society free of charge. It is very certain that without the constant help of the Committee and of Mr. J. E. Phillips, the Exhibition Manager, the Society would not have been able to stage anything like so large an exhibit as they did.



General view of gallery and cases.

In addition to the Historical Exhibit the Society organised an Inventions Section, which proved very successful and attracted wide attention. A list of the inventions shown is given in the following pages. The aim of the Inventions Section was to enable inventors who had inventions of possible value that had not yet reached the commercial stage, to get in touch with those who might be interested, and undoubtedly that object was achieved.

During the Exhibition the Society arranged a series of lectures on aeronautical progress in France, Holland, Italy, Sweden and Great Britain by leading authorities. These lectures are printed elsewhere in this issue. Additional *ex tempore* lectures were given by Captain Kingsford Smith and Mr. Ulm, and

by the Hon. M. L. Finlayson, Minister of Lands and Forests for the Government of Ontario, Canada; the former on their Pacific flight and the latter on Forest Fire-Fighting in Canada.

In co-operation with the Air League of the British Empire a series of remarkable aeronautical films was shown in the Concert Hall, and attracted over six thousand people. These films were technical, semi-technical and popular. The Society were fortunate in having the co-operation of Captain Williams, of the Air League of the British Empire, who was largely responsible for the success of the Cinema Section of the Exhibition.

The Society's Information Bureau.

Finally, the Society were responsible for the visits of thousands of school children in specially organised parties. The work of arranging these visits involved weeks of preparation, and the actual organisation both before and during the Exhibition was largely in the hands of Miss N. G. Jones, to whose ability not a little of the success of this side of the Society's activities was due.

During the Exhibition the Society published a Souvenir Booklet which gave an historical account of the Society by Mr. J. E. Hodgson, and a brief outline, illustrated, of the exhibits. This booklet, together with the account now printed,

gives a complete account of the activities of the Society at the International Aero Exhibition, July 16th-27th, 1929.

STAND NO. 222

In this part of the Society's exhibit were shown on a long deep panel, engravings, drawings, posters and photographs illustrating the development of Aeronautics from the invention of the balloon down to 1914. In addition there were twelve double cases containing rare books, pamphlets, MSS., etc., covering the story of flight from the earliest times.

CASE I.

Early Notions of Flight and Historic Aeronautical Projects (British).

About 850 B.C.

THE BRITISH KING WHO TRIED TO FLY

Bladud, the ninth (legendary) King of Britain, is said to have made a pair of wings with which he tried to fly. His wings failed him, and falling from the top of Apollo's Temple in Trinobantum (that is London) he broke his neck.

Lent by Mr. J. E. Hodgson.

850 B.C.

THE FLYING KING OF BRITAIN

The legend of the Flying King of Britain is retold in "The Fables of Unfortunate Princes," 1619. This 17th century version of the story of Bladud (the father of Shakespeare's King Lear) is here elaborated in picturesque verse, concluding with the now obsolete moral:—

"On high the tempests have much power to wreck:
Then best to bide beneath, and surest for the neck."

Lent by Lt.-Col. W. Lockwood Marsh.

About 1250

ROGER BACON ON FLYING

The earliest speculations on Mechanical Flight may be seen in Roger Bacon's treatise on the "Secrets of Art and Nature." His idea was that flight would be achieved by the use of artificial wings, and he states he knew a man who had invented such a machine. The photograph shows a page of a 13th century Manuscript in the Bodleian Library, Oxford, containing the passages referred to.

1559

THE LEGEND OF KING BLADUD

An early edition of the Chronicle of Robert Fabyan, in which the legend of the "Flying King of Britain" was first printed in English. In Fabyan's quaint wo' is Bladud in attempting "to flie in the aire . . . fell upon the temple of his God Apolin, and thereon was all to torne."

Lent by Messrs. McLeish & Sons.

1597

ROGER BACON ON FLYING MACHINES

The extremely rare First Edition of the earliest English translation of Roger Bacon's Latin treatise—written about 1250—containing his reference to the possibility of making "an Instrument to Flie withall."

Lent by Sir Leicester Harmsworth.

1648

BISHOP WILKINS ON THE ART OF FLYING

A learned treatise on "Mathematicall Magick," containing four chapters on the making of Flying Machines. Wilkins conceived four possible methods of Flight:—by Spirits or Angels, by the help of fowls, by Wings fastened to the body, and by a Flying Chariot.

Lent by Mr. J. E. Hodgson.

1654

KITES IN THE SEVENTEENTH CENTURY

The earliest known English woodcut illustration of Kite-flying. This book is a treatise on "The Composing of all Manner of Fier-Works," by John Bate, and tells how to make "Balloons," a word then used for a firework shot out of a mortar.

Lent by Mr. J. E. Hodgson.

1657

THE FIRST ENGLISH "FLYING" ROMANCE

Bishop Godwin's "Man in the Moone" tells of an imaginary lunar voyage by the help of "gansas" or large birds. This method of aerial travel begins with the story of Alexander the Great, and was revived in England as late as 1835. Godwin was the first to express the idea that the "first Flying Man" would be entitled to great honour.

Lent by Mr. J. E. Hodgson.

1679

FIRST SCIENTIFIC SPECULATIONS ON FLIGHT

Robert Hooke, a distinguished 17th century scientist and mechanician, is the first man of learning known to have made experiments in Aeronautics. In this book he criticised two contemporary schemes—Lana's "Flying-Boat" and Besnier's Flying Machine, the former representing the "lighter" and the latter the "heavier-than-air" method.

Lent by Mr. J. E. Hodgson.

1684

WILKINS' VOYAGE TO THE MOON

A scientific treatise on the possibility of the Moon being a habitable World, and the even more remote possibility of flying there. Wilkins calculated that flying 1,000 miles a day it would take 180 days to reach the Moon.

Lent by Messrs. McLeish & Sons.

1687

CYRANO'S VOYAGES TO THE MOON, ETC.

In these satirical romances the aerial flights to the Moon and the Sun are achieved by such chimerical means as the ascensive power of dew contained in glass-balls, or the attractive power of the load-stone.

Lent by Mr. J. E. Hodgson.

1695

SEVENTEENTH CENTURY DIALOGUE ON FLIGHT

An English translation of Fontenelle's "Entretiens sur la Pluralité des Mondes," which contains some remarkably far-sighted and prophetic speculations on the progress of Flight compared with the development of Navigation—as the open pages show.

Lent by Mr. J. E. Hodgson.

1751

PALTOCK'S FLYING ROMANCE OF "PETER WILKINS"

A Desert-island story in which the hero, Peter Wilkins—a second Robinson Crusoe—discovers an extraordinary race of Flying Men and Women. The author was the first to describe fights between armed forces in the Air. But unlike the "real thing," the fire of these guns proves so accurate that the gunner is nearly crashed to death by the enemy who "crash" all round him!

1751

EIGHTEENTH CENTURY FLYING CONTEST

An imaginary aerial contest between:—
"The one a German of distinguish'd fame:
His rival from projecting Britain came,"
in which the Englishman, contrary to all sportsmanlike British traditions, evades defeat by pulling down his rival. The German's wings are copied from the primitive flying-machine, used nearly 100 years earlier by the Frenchman Besnier.

Lent by Mr. J. E. Hodgson.

1759

DR. JOHNSON ON THE ART OF FLYING

The rare First Edition of Johnson's romance of "Rasselas," which contains a chapter on the art of Flying with wings. In it the author foreshadowed the principle of Heavier-than-Air Flight in the prophetic words: "You will be upborne by the air if you can renew any impulse upon it faster than the air can recede from the pressure."

Lent by the Norwich & Norfolk Library.

1769

GODWIN'S FLYING ROMANCE

The aerial adventures of Domingo Gonsales had a considerable vogue, and the story was translated into continental languages. The engraving in this 18th Edition quaintly depicts the devils who assailed Gonsales during his flight.

Lent by Mr. J. E. Hodgson.

CASE II.

The Invention of the Balloon.

1766

DR. JOSEPH BLACK

A distinguished Scottish scientist who was the first to suggest, on hearing of Cavendish's discovery in 1766 of the atomic weight of Hydrogen, that a bladder inflated with "inflammable-air"—as it was then called—would float in the air. But it is doubtful if Black ever demonstrated the fact by experiment.

Lent by Mr. J. E. Hodgson.

1783

FIRST ENGLISH TREATISE ON BALLOONS

An early description of Montgolfier's invention, with accounts of the first Balloon ascents in France. The writer suggests Balloons would be useful for Military purposes, for locating fires in large towns, and for affording invalids a "change of air."

Lent by Mr. J. E. Hodgson.

1784

ADVERTISEMENT OF THE FIRST PROJECTED BALLOON ASCENT

A highly-coloured announcement of the first Balloon exhibited in London. The art of the advertiser to-day could hardly excel the statement that this Balloon exhibited "the appearance of a huge world, invisibly suspended by Omnipotence, floating in the incomprehensible infinity of space."

1784

FIRST EXPERIMENT IN AERONAUTICS MADE BEFORE ROYALTY IN ENGLAND

King George III. was the first British Sovereign to witness an experiment in aeronautics. The two quaint contemporary engravings on the left show him watching the ascent of a small Hydrogen Balloon, released by Argand, the famous Swiss scientist, from the grounds of Windsor Castle. Of the two other prints, the one above depicts a scientist explaining the nature of a hydrogen balloon. The one below is a caricature of the balloon.

1784

LUNARDI'S FIRST AERIAL VOYAGE

Bronze medal struck in commemoration of the first Aerial Voyage in England. Shortly after rising from the ground Lunardi dropped a flag—shown in the medal—and then an oar. It is said that a woman, mistaking the oar for the body of Lunardi, fell down dead on the spot.

Lent by Mr. J. E. Hodgson.

1784

ADMISSION TICKET FOR BLANCHARD'S ASCENT FROM CHELSEA

Note the early use of a fan or air-screw, by means of which Blanchard erroneously maintained he was able to direct his Balloon. The ticket is signed by the aeronaut.

Lent by Mr. J. E. Hodgson.

1785

CAVALLO'S HISTORY OF AEROSTATION

A "grangerised" or extra-illustrated copy of the first scientific history of Ballooning in English. This interesting book formerly belonged to Robert Cocking, the parachutist. One of the engravings inserted is an autographed portrait of Garnerin, the first man to descend in a parachute, by whom it was given to Cocking.

Lent by Mr. J. E. Hodgson.

1785

SOUTHERN'S TREATISE ON BALLOONS

One of the earliest works on the scientific principles and on the construction of Balloons. Southern was an assistant of the great James Watt.

From the Royal Aeronautical Society's Library.

1785

FIRST ENGLISH WOMAN AERONAUT

First Edition of Mrs. Sage's own account of her flight in Lunardi's Balloon—an excursion which she said pleased her more than any former event in her life.

Lent by Mr. J. E. Hodgson.

1785

LUNARDI'S AERIAL VOYAGES IN SCOTLAND

Lunardi was the first to make successful Balloon flights from Edinburgh, Glasgow, and Kelso. James Tytler, who had previously made unavailing efforts to ascend in his "Edinburgh Fire Balloon," contributed to this book verses in praise of Lunardi.

Lent by Mr. J. E. Hodgson.

1785

LUNARDI'S BALLOON ASCENTS FROM LIVERPOOL

The first Balloon Ascents from Liverpool were made by Vincent Lunardi in July and August, 1785. The author's printed accounts of his "voyages" are now very rare. The engraving shown was not issued with the book, but copies were dropped by Lunardi from the air.

Lent by Mr. J. E. Hodgson.

1785

POTAIN'S ATTEMPTED BALLOON FLIGHT ACROSS THE IRISH CHANNEL

This first attempt to cross by air from Ireland to England, made in June, 1785, by a French Naval Surgeon, ended in failure, and Potain had to land near Powerscourt.

From the Royal Aeronautical Society's Library.

1785

DEEKER'S BALLOON ASCENTS FROM NORWICH

The earliest Balloon ascents from Norwich. On the first occasion Deeker offered to take up Miss Weller, aged 14, as a passenger. Owing to bad weather this was deemed inadvisable, and the disappointed girl had to be dragged forcibly out of the car.

Lent by Mr. J. E. Hodgson.

1785

PORTRAIT OF MRS. SAGE

Mrs. Sage's flight was made, not, as is commonly thought, with Lunardi, but alone with George Biggin, who had never been up in a balloon before. The ascent was from St. George's Fields, and the landing near Harrow, a distance of 30 miles travelled in an hour and 35 minutes.

1786

BALDWIN'S AIROPAIDIA, OR AERIAL RECREATION

An account of an ascent in Lunardi's Balloon, made from Chester in September, 1785. The latter part of the book is a treatise on Ballooning, in which the author suggests the use of the "guide" rope—a practical idea in Balloon piloting, which was first adopted and developed by Charles Green.

Lent by Mr. J. E. Hodgson.

1790

PRIESTLEY'S EXPERIMENTS ON AIR

Joseph Montgolfier, the inventor of the Hot-Air Balloon, admitted having derived ideas from this work by the great English chemist, Joseph Priestley. Priestley himself took an active interest in Ballooning in quite early days, and invented an improved method of producing hydrogen for inflation.

Lent by Mr. J. E. Hodgson.

1803

MONEY'S TREATISE ON MILITARY BALLOONS

First English treatise on the use of Balloons for reconnaissance in Military Operations. Major Money made several flights in balloons, one of which—from Norwich in 1785—nearly cost him his life, owing to his coming down in the sea off Yarmouth.

Lent by Mr. J. E. Hodgson.

1785–1824

FRAGMENTS OF FAMOUS BALLOONS

These fragments were collected by John Cuthbert, a Ballooning enthusiast of over one hundred years ago. Note the frank admission that he himself cut the diminutive piece of Blanchard's Channel Crossing Balloon from the envelope in Calais Town Hall! A more precious fragment is that above—a charred particle of the Balloon in which Pilâtre de Rozier lost his life in June, 1785.

CASE III.

James Sadler (1751-1828). The First English Aeronaut.

1784–85

EARLY BALLOON VOYAGES IN ENGLAND

Contemporary Manuscript recording the earliest Balloon Ascents in England by Lunardi, Sadler, Blanchard, and others. The volume is open at an account of James Sadler's ascent from Manchester. The crude drawing shows the method of suspending the Balloon during inflation. The car is depicted with a rudder which it did *not* have.

Lent by Lt.-Col. W. Lockwood Marsh.

1785

URQUHART'S INSTITUTES OF HYDROSTATICS

An 18th century scientific treatise, with an Essay on "Air Balloons." The author concludes that no human art or knowledge can ever make Balloons "useful or safe vehicles of conveyance to mankind from place to place."

Lent by Mr. J. E. Hodgson.

WILLIAM WINDHAM SADLER'S COMPASS

James Sadler's younger son, William Windham, was named after the distinguished statesman who made an ascent in the elder Sadler's balloon from Moulsey Hurst in May, 1785.

Lent by Mr. Harold Sadler
(Grandson of Windham Sadler).

About 1800

WINDHAM SADLER, THE AERONAUT, AT THE AGE OF FOUR

William Windham Sadler was a son of James Sadler, the "Father of English Aeronauts." A pathetic interest attaches to the fact that the child is depicted playing innocently with a Toy Balloon, for twenty-eight years later Windham was killed in distressing circumstances near Blackburn, by a fall from his Balloon.

Lent by Mr. Harold Sadler.

1810

JAMES SADLER'S BALLOON VOYAGE FROM BRISTOL

The first of Sadler's Aerial Voyages to end in the water, from which both he and his passenger were rescued. In an endeavour to lighten the Balloon on this occasion, the Aeronaut threw overboard a heavy barometer given him by the great Dr. Johnson, for which he is said to have been offered £200.

Lent by Mr. J. E. Hodgson.

1811

SADLER'S ASCENT FROM BIRMINGHAM

Medal to commemorate Sadler's ascent from Birmingham, October 7, 1811. On this occasion the Balloon travelled 47 miles in 90 minutes—an "astonishing" speed, which at that date could only be described as exceeding that of the famous racehorse, "Flying Childers."

Lent by Mr. J. E. Hodgson.

1811
JAMES SADLER'S BALLOON
Part of the painted silk used in the decoration of a gorgeous car in which Sadler ascended from Burlington House, Piccadilly, in July, 1814.
Lent by Mr. Harold Sadler.

1812
JAMES SADLER'S ATTEMPT TO CROSS THE IRISH SEA
The Aeronaut's own account of his unsuccessful attempt. Sadler fell in the sea off Great Orme's Head and narrowly escaped drowning. (See the coloured engraving on the wall.) His son, Windham Sadler, was the first to cross from Dublin to Holyhead by Air in July, 1817.
Lent by Mr. J. E. Hodgson.

1812
SADLER'S ATTEMPTED IRISH CHANNEL CROSSING BY AIR
Though Sadler crossed the Channel from Dublin to Holyhead, he remained in the air in the hope of reaching Liverpool. Subsequently carried north by a change of wind, he was obliged to alight on the water, and was rescued by a fishing-boat in a very exhausted condition. Sadler at this date was over 60 years of age.
From the Royal Aeronautical Society's Library.

1814
JOHN SADLER'S BALLOON ASCENT FROM ST. JAMES'S PARK, AUG. 1, 1814
On this occasion John Sadler, the eldest son of James Sadler, was to have had a lady passenger. Owing to the high wind he declined to take her, despite her indignant protest that "what a man can do, a woman can do." The autograph below shows that this was Sadler's last ascent.

1817
FIRST CROSSING OF THE IRISH CHANNEL BY AIR
Windham Sadler, the son of James Sadler, succeeded where his father had failed. Having ascended from Dublin on July 22, 1817, at 1.30 p.m., he landed near Holyhead Lighthouse a few minutes after seven.
From the Royal Aeronautical Society's Library.

1824
LETTER FROM JOHN SADLER
Written to his sister after the death of their brother, Windham, giving some account of the latter's career and a list of his ascents. Among other incidents the writer tells how his brother, when quite a small boy, had walked from London to Oxford in 1810 to see the balloon ascent of his father, James Sadler. Arriving half-an-hour too late, he walked back to London!
Lent by Mr. Harold Sadler.

1824
AUTOGRAPH LETTER FROM WINDHAM SADLER
Probably the last letter written by Windham Sadler to his wife. He was killed near Blackburn on September 29, 1824, in an accident to his balloon, after an ascent from Bolton made in a high wind.
Lent by Mr. Harold Sadler.

CASE IV.

Victorian Balloonists: Charles Green, etc.

1836
GREEN'S BALLOON VOYAGE TO WEILBURG IN GERMANY
First Edition of Monck Mason's Account of the first Long-distance Over-sea Aerial Voyage from England. The distance from Vauxhall Gardens to Weilburg, Nassau, nearly 500 miles, was completed in 18 hours.
Lent by Mr. J. E. Hodgson.

1836
GREEN'S VICTORIA AND NASSAU BALLOONS
Fragments of the silk used for the envelopes of the two balloons in which Charles Green made the great number of 500 ascents. The Nassau (originally Vauxhall) Balloon was constructed in 1836 and was used by Coxwell as late as 1873—a remarkable record.
Lent by Mr. J. E. Hodgson.

1836
GREEN'S VOYAGE TO WEILBURG
Latin verses printed at Weilburg in praise of Charles Green's aerial voyage. Note the novel variation on our national song. Doubtless these headlines appealed to Green as a good Englishman, more than the learned verses he could not understand!
Lent by Mr. J. E. Hodgson.

1850
FRAGMENT OF MRS. GRAHAM'S BURNT BALLOON
One of Mrs. Graham's many hazardous flights ended, after a landing at night near Edmonton, in the burning of her balloon. Beneath is a handbill in which she advertised herself as "Aeronaut to Her Most Gracious Majesty" Queen Victoria.
Lent by Mr. J. E. Hodgson.

1852
GREEN'S 500TH BALLOON ASCENT
The concluding Ascents in Green's long career as a pilot, were made the occasion of lotteries for free "joy-rides" in his balloon. Two of the tickets handed to visitors to Vauxhall Gardens are shown beside the handbill.
Lent by Mr. J. E. Hodgson.

1852
GRAHAM'S APPARATUS FOR STEERING BALLOONS
A contrivance of four flimsy wings worked with treadles by the pilot standing in the car. Graham's method of propulsion was based on "the principle of a dragon-fly or other insect with four wings."
Lent by Mr. J. E. Hodgson.

Case V.

Victorian Ballooning.

1785

PROSSOR'S "AERIAL COLLOSSUS"

A fantastic project for a Navigable Balloon. The inventor designed his Balloon to represent Sir John Falstaff, and gave the dimensions as 39 feet high and 69 feet "round the waist."

Lent by Mr. J. E. Hodgson.

1824

DEATH OF LIEUT. THOMAS HARRIS AT BEDDINGTON PARK, CROYDON.

Thomas Harris was the first English aeronaut killed during a flight in a balloon. His death was due to his own invention of a patent valve, which allowed too rapid an escape of gas, whereby the balloon crashed. The lady who accompanied Harris survived and subsequently made other ascents.

Lent by Mr. J. E. Hodgson.

1838

HOAR'S GREAT HOT-AIR BALLOON

The largest Hot-Air Balloon ever constructed in England. The lower fragment shows an unusual method of securing the cords by which the car was suspended. The car was intended to carry fifteen or twenty passengers.

Lent by Mr. J. E. Hodgson.

1838

FRAGMENT OF HAMPTON'S BALLOON

The miniature newspaper below these "doped" fragments of Hampton's Balloon was printed for the Aeronaut as an advertisement. Copies of the "Aerial Advertiser"—the earliest journalistic effort of the kind—were scattered from the Balloon in mid-air.

Lent by Mr. J. E. Hodgson.

1838

HOAR'S GREAT HOT-AIR BALLOON

This immense Montgolfière Balloon, the largest ever constructed in England, was 130 feet in height—as high as the Duke of York's Column. An attempted ascent, made under the "immediate patronage of Queen Victoria," on Her Majesty's Birthday, was a complete failure. Whereupon a riot ensued, and the Balloon was utterly destroyed by an enraged mob.

Lent by Mr. J. E. Hodgson.

1845

COXWELL'S "BALLOON MAGAZINE"

The first Aeronautical Magazine published in England. Coxwell, who was trained as a dentist, adopted a pseudonym for fear of displeasing his patients. As with several Aeronautical Magazines published at the beginning of this century, it only ran for four or five numbers.

Lent by Mr. J. E. Hodgson.

About 1850

HANDBILL OF COXWELL'S ASCENT AT BRUSSELS

Coxwell was the first to give demonstrations in Berlin and other Cities on the Continent of the possibility of Bomb-dropping from Balloons.

Lent by Mr. J. E. Hodgson.

1854

COXWELL ON BALLOONS FOR WARFARE

Coxwell was a firm believer in the use of balloons for reconnaissance in military operations. In this imaginary dialogue the "aeronaut" completely overcomes the scepticism of the "general." But despite the most persistent endeavours, Coxwell was unable to convince the War Office.

Lent by Mr. J. E. Hodgson.

1887

HENRY COXWELL'S "BALLOON EXPERIENCES"

Coxwell was the best-known Balloon Pilot of his day, and made over 1,000 ascents between 1844 and 1855. His most notable achievements were his high-altitude ascents with Glaisher, in several of which his balloon rose to between 20,000 and 30,000 feet.

Lent by Mr. J. E. Hodgson.

Case VI.

Sir George Cayley (1773-1857), the Father of Aeronautics.

The whole of the remarkable collection of Cayley's Aeronautical Papers contained in Cases VI. and VII. were exhibited by the courtesy of Sir Kenelm Cayley, Bart.

1800–1809

SIR GEORGE CAYLEY'S AERONAUTICAL NOTE-BOOK

The most important Aeronautical Manuscript of the period extant. It contains Cayley's observations on Bird-Flight, data of experiments with a Whirling Arm, and notes on his Flying Machines or Gliders. It also contains the earliest statement of Cayley's conviction that "Aerial Navigation" would certainly be achieved by the application of propelling apparatus to an inclined plane—in other words, on the principle of the Aeroplane.

1804

ORIGINAL MANUSCRIPT OF CAYLEY'S FIRST ESSAY ON AERIAL NAVIGATION

Refers to experiments during the previous eight or nine years, that is from 1795. On the opening page he writes:—"I am well convinced that Aerial Navigation will form a most prominent feature in the progress of civilization . . . and I am anxious that while foreign countries are displaying their attention to this subject, England should at least show a similar ardour."

1807–1853

CAYLEY'S HOT-AIR ENGINE

Cayley was so firmly convinced of the practicability of mechanical flight that he spent over forty years in intermittent work on a Hot-air Engine for Aerial Navigation. This letter of 8 pp. was written to Sir Goldsworthy Gurney, who collaborated with Cayley in the development—fruitless as it proved—of the air engine.

1809

DRAFT OF A LETTER FROM CAYLEY TO LORD MAHON ON DEGEN'S FLYING MACHINE

In this letter Cayley, while allowing that there had been hundreds of endeavours "from Daedalus to Bishop Wilkins," claims to be the first to have enunciated a "rational and systematic theory of the principles of Aerial Navigation." Degen, who was a clock-maker of Vienna, invented a winged flying-machine (shown in the plan) which proved a failure.

1816

CAYLEY ON AERIAL NAVIGATION

(Tillock's *Philosophical Magazine*, Feb., 1916)

In this essay Cayley first laid down the principle on which airship theory is mainly based—namely, that "the surfaces (and hence the resistance) increase as the squares of the diameter of the balloon, whereas the capacity to contain gas (and hence the supporting power) increases as the cubes of the diameter." This led him to advocate the construction of an airship 300 feet long.

1818

LETTER FROM CAYLEY TO LORD CAMPBELL

Copy of a long letter (five pages) on the principles of Mechanical Flight. The small sketch shows a primitive type of glider with which Cayley made countless experiments.

ca. 1830

CAYLEY'S FLYING OR GLIDING MACHINES

Rough sketches and notes of Experimental Flying Machines used by Cayley. On one sketch he gives the weight of the machine 110 lbs., and "my own weight 160 lbs." On another he illustrates his appreciation of the very great importance of reducing resistance by showing a strut "ovalled off," that is stream-lined.

About 1837

CAYLEY'S EXPERIMENTS ON THE RESISTANCE OF AIR

A simple contrivance for measuring the resistance offered by the air to a falling body. Cayley's primitive experiments in aerodynamics were carried out with great care. Note, for example, his working out of the average of eleven trials, timed with a stop-watch marking one-fifth of a second.

1837

CAYLEY'S PRACTICAL REMARKS ON AERIAL NAVIGATION

(*Mechanics' Magazine*, March, 1837)

A further examination of airship theory and the need for immense dimensions — the equivalent of a "hundred-gun ship," involving "acres of cloth" in the construction. Cayley urged an unflinching investigation of the practicability of airships on the ground that they would afford "the floatage of an uninterrupted ocean from every man's door to any other point on the globe."

1841

MANUSCRIPT OF CAYLEY'S SPEECH ON A PROPOSED ROYAL AEROSTATIC INSTITUTION

Cayley first suggested the formation of a Society to advance the cause of Aerial Navigation as early as 1817. On both occasions the suggestions fell through for lack of support, though in 1841 a printed prospectus was issued advocating experiments with Dirigible Balloons.

1843

ORIGINAL MANUSCRIPT OF CAYLEY'S LETTER "ON THE PRINCIPLES OF AERIAL NAVIGATION"

In this article (printed in the *Mechanics' Magazine* for April, 1843) Cayley, in commenting on Henson's "Ariel," develops his own ideas on Mechanical Flight, and suggests, for the first time, the idea of a bi-plane or tri-plane. But he also re-affirms his conviction that "Balloon navigation on a large scale" would "offer greater facilities for transporting men and goods through the air than mechanical means alone."

About 1850

LETTER FROM CAYLEY TO HIS MECHANIC

Giving instructions as to the construction of a "tension" wheel, to be used on a flying machine. At the end is a warning against "rash trials with this dangerous machine," rough drawings of which accompany the letter.

1853

CONTEMPORARY TRANSCRIPT OF CAYLEY'S ESSAY ON ARTIFICIAL FLIGHT

This essay, mainly dealing with experiments to be made with a form of "glider," was contributed to the Bulletin of the Société Aerostatique et Météorologique de France for October, 1853. A copy of the Bulletin corrected by M. Dupuis-Delcourt, the French aeronaut, is also shown. The essay was accompanied by drawings, only one of which was reproduced.

Case VII.

Sir George Cayley and the earliest pioneers of the Aeroplane, Henson and Stringfellow.

1799–1883

JOHN STRINGFELLOW, OF CHARD, "THE FATHER OF AVIATION"

Though Stringfellow was a member of the Society from 1868 onwards, he first engaged in experiments with flying machines at least as early as 1842. In 1848 he constructed the historic model "monoplane," which, driven by a small steam-engine working twin propellers, flew for a short distance under its own power.

1818

CAYLEY'S EXPERIMENTS ON NAVIGABLE BALLOONS

Bill for the materials and making of an oblong balloon, with Cayley's plan of the same. Also two drawings of a later date (1835) showing the "stream-line" form of the body of a salmon, as suitable for a dirigible balloon.

1837

LETTER TO CAYLEY ON AEROSTATION

A specimen of the many letters written to Cayley by would-be inventors and enthusiasts on air navigation. The patriotic appeal made in this instance hardly rings true over such a signature!—J. C. G. Schönherr.

1846

LETTER TO CAYLEY ON AIRSHIPS

Another typical letter, advocating the construction of an aerostat (that is a balloon) measuring 1,250 feet in length, 150 feet in diameter, and capable of carrying 1,000 men! With a steam engine of 209 h.p. and a "propeller" 150 feet in diameter, this airship genius claimed his fantastic creation would have a speed of 80 m.p.h.

1840

LETTER FROM THE DUKE OF ARGYLL TO SIR GEORGE CAYLEY

A letter from the first President of the Royal Aeronautical Society to the "Father of Aeronautics."

1843

AUTOGRAPH LETTER FROM T. MONCK MASON (WHO ACCOMPANIED GREEN ON THE BALLOON VOYAGE TO WEILBURG IN 1837)

Written by Monck Mason to Sir George Cayley, describing at length a design for an elongated screw-propelled Dirigible Balloon, with a sketch of the same bearing comments in Cayley's hand.

1843

MONCK MASON'S ELLIPSOIDAL BALLOON

Experiments with a working model, 44 feet long, inflated with hydrogen, were made at the Royal Adelaide Gallery in the Strand. The model was propelled at a rate of six m.p.h. by a section of an Archimedean screw, actuated by clockwork.

1846

AUTOGRAPH LETTER FROM W. S. HENSON, INVENTOR OF THE "ARIEL" MONOPLANE

This interesting letter is addressed to Sir George Cayley as the "Father of Aeriel Navigation," asking for financial help. It is accompanied by the draft of Cayley's reply, pointing out, with tragic foresight, that "a hundred necks have to be broken before all the sources of accident can be ascertained and guarded against."

1850

POSTER OF BELL'S LOCOMOTIVE BALLOON

Note the attractive statement that this trial of a Navigable Balloon would probably prove "the most astounding Aeronautic attempt ever made." But advertisements, whether of the past or of to-day, are sometimes too good to be true! Here the delusion is rudely dispelled by the manuscript note added by an eye-witness—"An Entire Failure."

Lent by Mr. J. E. Hodgson.

1850

AUTOGRAPH LETTER FROM HUGH BELL

(Inventor of the "Locomotive Balloon")

This letter to Cayley gives particulars of Bell's Cylindrical Balloon with conical ends. The writer states that with a screw-propeller worked by himself he hoped to attain a speed of 3 m.p.h.

1850

BELL'S LOCOMOTIVE BALLOON

The first Navigable Balloon to be flown in England. It was 50 feet long, to be driven by propellers worked by hand. When tried from Vauxhall Gardens it was said that, despite the vigour with which the aeronaut "twirled his wheels and flapped his tail," the balloon drifted wherever the wind carried it!

Lent by Mr. J. E. Hodgson.

1851

MANSFIELD'S AERIAL NAVIGATION

(By means of Dirigible Balloons)

The earliest exhaustive treatise on the problems involved in Airship construction and navigation—shape, buoyancy, stability, resistance, propulsion, control, and "anchorage." Mansfield, who was a distinguished chemist, wrote this book in 1851, but it was not published till after his death. A long letter from Mansfield to Cayley is also exhibited.

1853

MOAT'S STEAM FLYING MACHINE

A bold conception of Mechanical Flight over seventy years ago. Moat claimed his machine of twenty tons weight would travel over 100 miles per hour. He maintained that aerial locomotion must bring about "the greatest change ever effected in the history of the race." Wrong in his belief that the first effect of air machines would be to stop wars, he was right in asserting that they would "unite friends."

Lent by Mr. J. E. Hodgson.

CASE VIII.

The Development of the Airship (1784-1918).

1835

FRAGMENTS OF LENNOX'S "EAGLE"

These fragments of Lennox's "Eagle" Airship, which was constructed in London—but never flown—consist of:

1. Part of the "doped" Envelope (2,700 cubic feet capacity).
2. Webbing used for strengthening the Envelope.
3. Netting over the Envelope.
4. Canvas Belting to enclose passenger accommodation.
5. Fabric to cover the Machinery Cabin.

Lent by Mr. J. E. Hodgson.

1847

LUNTLEY'S DIRIGIBLE BALLOON

Luntley's first project for a Dirigible (63 feet long) combined a Balloon with the large Wings of a Flying Machine. The latter were to be operated by a type of explosion engine, the charge of gas being fired by an electric current.

From the Royal Aeronautical Society's Library.

1851

LUNTLEY'S ROTARY BALLOON

Luntley was one of the few men of his time who turned in 1847 from experiments with Flying Machines (ornithopter with gas-engine) to Dirigible Balloons. His Rotary Balloon was criticised by Sir George Cayley as wholly impracticable—which indeed it looks! Luntley was probably the first to suggest using gas from the envelope of his dirigible as fuel for the engine.

Lent by Mr. J. E. Hodgson.

1879

BRANNON'S AIR BOAT OR ARCUSTAT

Brannon, a civil engineer, had unbounded faith in the possibilities of "Air Travel," which he described as "the SAFEST, SUREST, SWIFTEST, HEALTHIEST, MOST DELIGHTFUL, and CHEAPEST MEANS OF LOCOMOTION GOD HAS GIVEN TO MAN."

Lent by Mr. J. E. Hodgson.

1902

BARTON'S AIRSHIP

After experiments over 19 years, Dr. F. A. Barton designed an airship combining the lift of a cigar-shaped balloon—180 feet long, with a capacity of 156,000 cubic feet—with a series of multiple aeroplanes. Barton built a second ship to the order of the War Office, but despite a "most successful trial"—see the accompanying letter—the combination of methods proved a failure.

Lent by Spencer Bros., Ltd.

1902

THE SPENCER-MELLIN AIRSHIP

Designed, built, and flown by the firm of Spencer for the proprietors of Mellin's Food. The envelope had a capacity of 20,000 cubic feet, and was 75 feet in length. The propeller of light pine was driven by a 6/8 h.p. Simms petrol motor.

Lent by Spencer Bros., Ltd.

1919

"THE LOG OF R.34"

Author's Manuscript and Typescript copy of the diary of Air-Commodore E. M. Maitland, C.M.G., D.S.O., written during the famous voyage of R.34, July 2–13, 1919. This was the first Crossing of the Atlantic by Airship. The outward passage, East Fortune to New York, took 4 days 12 hours, and the return to Pulham (with prevailing westerly winds) 3 days 3 hours.

Lent by Sir Charles Wakefield, Bart., C.B.E.

1919

THE COPY OF KIPLING'S "ACTIONS AND RE-ACTIONS" CARRIED TO AMERICA AND BACK IN R.34

This volume of Kipling, containing his story of "With the Night Mail," has the unique distinction of having flown to New York and back by Air. It was taken by Air-Commodore E. M. Maitland, who subsequently got it signed by the officers and crew of R.34 for presentation to the Author.

Lent by the courtesy of Mr. Rudyard Kipling

1920

KIPLING'S "WITH THE NIGHT MAIL"

Autograph Presentation Copy of the volume containing Kipling's well-known yarn of the Atlantic Air Mail. The author gave it to Air-Commodore E. M. Maitland after the historic Atlantic Flight of R.34. The value of an ordinary copy of this edition is about 10/–, but the unique copy here exhibited is worth nearer £200.

Lent by Sir Carles Wakefield, Bart., C.B.E.

Case IX.

The Royal Aeronautical Society.

1841

HAMILTON'S "ART OF FLYING"

Hamilton's ideas were based on Ornithopter Flight with Wings, but they are only vaguely set down. He realised the dangers of flying, and in the manner suggested much earlier by Leonardo da Vinci—he proposed the use of a "breast-plate of caoutchouc blown out with air to save the 'flyer' from bruises!"

From the Royal Aeronautical Society's Library.

1865

HATTON TURNOR'S "ASTRA CASTRA"
(Experiments and Adventures in the Atmosphere)

A ponderous pot-pourri of Ballooning history, consisting for the greater part of quotations from earlier books on the subject, interspersed with an inordinate amount of dull verse. The value of the book as a reliable history may be judged from the fact that Sir George Cayley is barely mentioned. This is a specially bound copy presented by the Author to the Society, of which he was a member.

1866

THE SOCIETY'S FIRST PUBLICATION

A paper on the Society's primary aims read by F. W. Brearey, the first Hon. Secretary, who held that post until his death in 1896. In the accompanying letter Brearey deplores the apathy of "supposed and published supporters"—the Society, he adds, "seems to consist entirely of myself."

From the Royal Aeronautical Society's Library.

1866

WENHAM'S CLASSIC TREATISE ON "AERIAL LOCOMOTION"

F. H. Wenham, one of the greatest pioneers of Mechanical Flight in England in the last half of the nineteenth century, carried out numerous experiments with model "Aeroplanes." The plate shows some types of Monoplane, Bi-plane and Multi-plane machines which Wenham designed. The treatise (with additional matter) was published as the first of the Aeronautical Society's Annual Reports.

1871

FIRST EDITION OF GLAISHER'S "TRAVELS IN THE AIR"

James Glaisher, meteorologist and founder of the Society, made many Balloon ascents for scientific purposes. The engraving shows the famous incident during a record flight with Coxwell from Wolverhampton on September 5, 1862. At a height of about 30,000 feet, Glaisher became insensible, while Coxwell, having lost the use of his hands, just managed to pull the valve cord with his teeth. A safe landing was eventually made near Ludlow.

Lent by Mr. J. E. Hodgson.

1871

GLAISHER'S "TRAVELS IN THE AIR"

The Second Edition. It is said that the brothers Short started off their aeronautical career as a result of reading this book—just as the brothers Lilienthal did from reading the pioneer ballooning adventures of Zambeccari. This copy formerly belonged to Philip Brannon, a civil engineer and inventor (on paper only!) of a wonderful "Air-boat."

Lent by Mr. J. E. Hodgson.

1895

FRAGMENT OF MAXIM'S FLYING MACHINE

Specimen of the Fabric used to cover the Wings of Sir Hiram Maxim's second "Flying Machine."

Lent by Mr. J. E. Hodgson.

1904

CODY'S MAN-LIFTING KITES

Before Cody became engaged in the construction of his aeroplanes, he had made numerous experiments with Man-lifting Kites. He gave demonstrations of these before the authorities of the Admiralty and the War Office. The extraordinarily varied character of Cody's career is further shown in the accompanying programme of a tour with his Theatrical Company.

1905

FROST'S ORNITHOPTER MACHINE

Experimental "flying" machine, the wings built up of real feathers. Frost was a keen supporter of the Society, of which he became President. These wings are preserved in the Science Museum, but without the wheeled frame-work—a very necessary part of the apparatus.

Lent by Mr. J. E. Hodgson.

1909

THE SOCIETY'S BRONZE MEDAL

The Bronze Medal is awarded under similar conditions to the Silver Medal—that is for some advance in aeronautical design. The present one was awarded in 1909 to Dr. F. W. Lanchester, by whom it is lent.

1909

THE SOCIETY'S GOLD MEDAL

The Gold Medal is the Society's highest award, and was first presented to the Wright brothers in 1909. This particular Medal is shown by the courtesy of Dr. F. W. Lanchester, to whom it was awarded in 1926 for his notable contributions to the Science of Aerodynamics (published 1907-8).

1910

THE SOCIETY'S SILVER MEDAL

The Silver Medal was originally intended as an award for the Kite Flying Competition at Worthing in 1903, but it was not presented as no kite fulfilled the conditions. The bird in the design is a peregrine hovering, from a drawing by Joseph Wolf. It was first presented to S. F. Cody in 1910. The present Medal was awarded to Capt. G. S. Wilkinson, by whom it is lent.

1910

ROLLS' CROSS-CHANNEL FLIGHTS

Telegram of congratulation from Their Majesties the King and Queen.

Lent by Lady Shelley-Rolls.

THE HONBLE. C. S. ROLLS

Charles Stuart Rolls (1877–1910), at one time a keen balloonist, became a member of the Society in 1901. Subsequently he accomplished some notable aeroplane flights but was killed when flying a Wright machine at the Bournemouth Aviation Meeting in 1910. The small diary is a record of his early flights.

Lent by Lady Shelley-Rolls.

1911

BRYAN ON STABILITY IN AVIATION

For his important work on stability the late Professor G. H. Bryan was awarded the Society's Gold Medal in 1914.

From the R.A.S. Library.

CASE X.

Development of the Parachute.

1785

FIRST PARACHUTE ATTEMPT IN ENGLAND

View of St. George's Fields and the Old Surrey Theatre with Arnold's Balloon. The parachute was knocked off in rising above the masts and the affair proved a failure.

Lent by Mr. J. E. Hodgson.

1787

BLANCHARD'S BALLOON ASCENT AT NUREMBERG

The citizens of Nuremberg paying tribute to the French aeronaut, "nach Englischer weise"—that is, "after the English fashion," by drawing his carriage through the streets. This book contains several German leaflets printed in praise of Blanchard's Balloon ascents, during several of which he experimented with small parachutes.

Lent by Mr. J. E. Hodgson.

1802

GARNERIN'S PARACHUTE

Garnerin was the first to make a parachute drop from a Balloon in England in 1802. This engraving of his first descent at Paris in 1797, was given by Garnerin to Robert Cocking, the parachutist.

Lent by Mr. J. E. Hodgson.

1837

COCKING'S PARACHUTE BENEATH THE NASSAU BALLOON

The ascent was made from Vauxhall Gardens, with Charles Green as pilot. When over Lee at about 5,000 feet, Cocking released the parachute, which almost immediately crumpled up and he crashed to the ground. Above is a small piece of the fabric of the parachute.

1838

JOHN HAMPTON, FIRST ENGLISH PARACHUTIST

Hampton, a popular balloonist of his day, was the first Englishman to descend in a Parachute from a free balloon. This he did at Cheltenham on October 3, 1838.

1854

LETUR'S FATAL FLYING MACHINE AND PARACHUTE

Letur's idea was to be carried up beneath a Balloon from Cremorne Gardens, and then perform a sensational flight from mid-air. But his impossible machine struck the trees in rising, and he died as the result of the terrible injuries received.

Lent by Mr. J. E. Hodgson.

1928

THE THIRD AND FOURTH GENERATIONS OF A FAMILY OF BALLOONISTS

The family of Spencer as balloonists and parachutists, starts with Edward Spencer, who made ascents in early Victorian days with Charles Green. His son, Charles Green Spencer, made a profession of ballooning, in which he was followed by his six sons. One of them, the late Henry Spencer, is here seen about to ascend, with his son, Mr. Percival Spencer, standing in the hoop.

Lent by Spencer Bros., Ltd.

CASE XI.

Pioneers of Gliding and Flight.

1870

HARTE'S THEORY OF FLIGHT

Contains early suggestions on wing-flaps or "ailerons" for use in controlling mechanical Flying Machines, as shown in the Patent Specification (No. 1469, May, 1870). Harte also suggested the use of variable pitch airscrews.

Lent by Mr. J. E. Hodgson.

1873

PETTIGREW'S "ANIMAL LOCOMOTION"

The author carried out many scientific experiments with Artificial Wings, in order to elucidate the principles of Winged Flight as seen in Birds and Insects. He expressed the belief that there was no more important mechanical problem than that of Aerial Navigation.

LAWRENCE HARGRAVE'S LETTER BOOKS

One of several thick albums of memoranda, drawings, letters, etc., now in the Society's possession, which bear witness to the immense amount of experimental work undertaken—with quite inadequate contemporary recognition, as is the lot of pioneers—by Hargrave, over a period of many years from about 1884 onwards.

Lent by R.Ae.S.

1895

PILCHER'S "BAT"

Manuscript notes on the "Bat," with account of expenditure on materials, *e.g.*, Sail material, 12 –; Wood for panel-work, 10 –; Pins, Tape, etc., 3 7; Tacks, 3½d. Also a specimen of the fabric used for the wings.

Lent by Mrs. Tidswell.

1895

PILCHER'S FIRST GLIDER "THE BAT"

Notes on the construction of "The Bat," with a sample of nainsook fabric used for the wings. Pilcher's Gliders had a surface of from 150 to 300 square feet, the latter being the size of the machine used by Sir George Cayley as early as 1809.

Lent by Mrs. Tidswell.

1896

PILCHER'S "HAWK" GLIDER

Fragments of the spars and fabric of "The Hawk." This glider weighed 50 lbs., and in it Pilcher dispensed with a vertical rudder. He made several glides on it at Eynsford, the longest being about 100 yds.

From the Royal Aeronautical Society's Collection.

1896–97

PILCHER'S GLIDER "THE HAWK"

Original scale drawings by Percy Pilcher. One shows a rough plan of a small oil engine which he designed for use in a glider, and which, with a "pusher" propeller, he anticipated would give a speed of about 30 m.p.h. But he did not live to test.

Lent by Mrs. Tidswell.

1897

PILCHER ON GLIDING FLIGHT

Author's corrected typescript—with additions in his sister's hand—of a paper read before the Royal Military Society of Ireland, at Dublin in January, 1897. In this paper Pilcher gave an account of Lilienthal's gliders, and of his own experiences.

Lent by Mrs. Tidswell.

1909

MODEL OF A HARGRAVE KITE

Model made by Lawrence Hargrave himself of Kites used in his experiments. This model was made to illustrate a paper on "Rigid Stable Aeroplanes," 1909, and it was presented to the Society by Hargrave's sister, Mrs. William Gray.

1909

FIRST FLYING MEETING IN ENGLAND

Official Programme of the First Flying Meeting in England, held at Doncaster in October, 1909. The only English competitors were Cody, who became naturalised during this meeting; Captain Windham, who never got off the ground; and Edward Mines on his so-called "coffee-stall" biplane.

Lent by Mr. J. E. Hodgson.

1910

EARLY CATALOGUE OF "AVRO" MACHINES

An early catalogue of the world-famous "Avro" machines—both triplanes, biplanes and monoplanes.

Lent by Mr. J. E. Hodgson.

1911

T. W. K. CLARKE & CO.'S CATALOGUE OF AERONAUTICAL ACCESSORIES

An early Aeronautical Catalogue, including Spars, Wing Frames, Fabrics, Propellers, etc. Clarke's claimed to be the "first firm of Aeronautical Engineers established in this country for the construction of Aeroplanes."

1920

DINNER TO THE SURVIVORS OF THE FIRST HUNDRED BRITISH AVIATORS AND PIONEERS OF AVIATION

A large number of the guests present at this historic dinner were members of the Society.

CASE XII.

Old-time Aeronautical Curiosities.

1783

COMIC BALLAD ON BALLOONS SET TO MUSIC

An early comic song on Ballooning, written before an Air Balloon had been seen in England. The idea of using Balloons for the invasion of these Islands is here treated humorously, but it gave rise to many wild rumours in the Napoleonic Wars.

Lent by Mr. J. E. Hodgson.

1783

FIRST ENGLISH CARICATURE ON BALLOONS

The invention of the Balloon was widely regarded in England as useless, and as a subject for ridicule. This small print is a skit on Montgolfier's experiment at Versailles in September, 1783, when a sheep, a cock, and a duck were made to play the part of the first living "aeronauts."

Lent by Mr. J. E. Hodgson.

1784

DECORATIVE BALLOON FABRIC

A fragment of contemporary Balloon fabric taken from a bed-hanging at Rochester. The fabric is printed with a design showing Lunardi's Balloon.

Lent by Mr. J. E. Hodgson.

1784

BALLOON SOUVENIR PATCH BOXES

The 18th century equivalent of the present-day vanity or powder box, with a mirror in the lid. That on the left depicts Lunardi's Balloon, and the other was a fitting souvenir of the ascent of a Birmingham hairdresser named Harper, who acquired James Sadler's first balloon.

Lent by Mr. J. E. Hodgson.

1784

BRISTOL-DELFT PLATE WITH A DESIGN OF LUNARDI'S BALLOON

Though the invention of the Balloon excited great interest in England it did not call forth such large quantities of souvenir pottery as were manufactured in France. The plate exhibited is a very rare specimen of English Balloon Pottery.

Lent by Mr. J. E. Hodgson.

1784

MUSIC COMPOSED FOR LUNARDI'S BALLOON ASCENT

This March was composed by Samuel Wesley (son of John Wesley, the hymn writer) to celebrate the first Balloon ascent in England. The earliest and possibly the only orchestral composition written to celebrate an achievement in Aeronautics.

Lent by Mr. J. E. Hodgson.

1788

EARLY BALLOON PLAY

Several plays about Balloons were produced in England, as on the Continent, owing to the extraordinary interest aroused by the invention. In this farce a Doctor, a Cobbler, and his wife, ascend from Wapping, and unable to control the Balloon, they eventually find themselves in an Indian garden adjoining the seraglio of the Mogul, where the play is enacted.

Lent by Mr. J. E. Hodgson.

1786

FIRST BALLOON ASCENT AT SALISBURY.

Street Ballad printed at Salisbury as a souvenir of the first Balloon ascent from the Castle Yard in August, 1786, by a Frenchman named Saint-Croix. The event was described at the time as "the grandest spectacle ever seen in England."

Lent by Mr. J. E. Hodgson.

1786

BALLOON NEEDLEWORK PATTERN

Needlework Pattern (dated 1786) for a lady's pocket. The design commemorates Lunardi's first ascent in September, 1784. Note the cat and dog in the car, two animals which Lunardi took with him on his Aerial Voyage.

Lent by Mr. J. E. Hodgson.

1810

AIR BALLOON TOY BOOK

A "Pantomime" in picture and verse, wherein the Balloon serves as a vehicle for a runaway pair. Note an early representation of the Parachute—made for two!—by means of which the lovers escape. Only one Parachute descent had been seen in England up to date of this quaint and rare booklet.

Lent by Mr. J. E. Hodgson.

1823

BALLOON TOKENS

Bronze tokens issued by Isaac Earlysman Sparrow, a London ironmonger, to commemorate his ascent with Charles Green from Oxford. Sparrow paid £50 for his seat in the car.

Lent by Mr. J. E. Hodgson.

1827

POCOCK'S CHAR-VOLANT OR KITE CARRIAGE

A novel but impracticable method of drawing carriages by means of Tandem Kites. Pocock once raced the Bristol coach over a stage of ten miles on the Bath Road—and won! To objections raised on the ground that the wind might drop, he replied that he intended to carry a pony on a trolley behind his "char-volant."

Lent by Mr. J. E. Hodgson.

CARICATURES ON AERONAUTICAL & MECHANICAL PROJECTS

The first half of the nineteenth century was a time of great mechanical activity, and witnessed countless schemes for the application of Steam, the use of Balloons, etc. The caricaturists ridiculed this rage for Machines by picturing impossible schemes of their own! Note the Airship destroying a Fleet at anchor.

Lent by Mr. J. E. Hodgson.

1835

COMIC BALLAD ON THE "AERIAL SHIP" SET TO MUSIC

The "Eagle" Airship created immense interest—until it was realised that no attempt would be made to fly it! It was then treated as a joke, and soon forgotten. One verse in the song runs:

"In London you may Breakfast take,
And as she nowhere tarries,
The Eagle will such progress make
That you may dine in Paris."

Lent by Mr. J. E. Hodgson.

1843

VICTORIAN LETTER PAPER

This imaginary view of an "Aerial Man" passing the Observatory in Greenwich Park is copied from the lithograph of a winged flying machine invented in 1843 by W. Miller.

Lent by Mr. J. E. Hodgson.

About 1850

CARICATURE ON THE CRINOLINE AS A PARACHUTE

A quaint jest on making a fashionable use of the principle of the Parachute. The "hint" must have been risky even with a full-blown crinoline—to-day it would certainly prove disastrous!

Lent by Mr. J. E. Hodgson.

Photographs of Early British Aeroplanes.

A remarkable collection of several hundred photographs relating mainly to the "Old Flying Days" was arranged on the panelled walls of the gallery. The descriptive cards given below deal with groups of photographs. Where possible acknowledgment has been given, but special acknowledgment should be made to Mr. C. G. Grey, Editor of *The Aeroplane*, who placed his unique stock of photographs at the disposal of the Society; to Mr. W. O. Manning, who gave the Society over a hundred and fifty negatives from his own valuable collection; and to Mr. Howard-Flanders for his invaluable help in arranging and identifying the photographs displayed.

1900

FASHIONABLE BALLOONING DAYS

The enjoyable though now obsolescent and "protected" sport of Ballooning enjoyed a final period of favour in the early years of this century. Balloon races from Hurlingham and Ranelagh were of frequent occurrence. One of the Spencer's balloons is here shown just leaving the ground.

Lent by Spencer Bros., Ltd.

1911

FIRST AIR MAIL IN THE UNITED KINGDOM

The first Aerial Post authorised by the Postmaster-General in England was inaugurated to celebrate the Coronation of H.M. King George V. The mail was flown from Hendon to Windsor between September 9th and 15th, 1911. It was organised by Capt. W. G. Wyndham, who in February, 1911, had also piloted the first Aeroplane Post in India, the latter being the earliest on record in any country.

Lent by Mr. J. E. Hodgson.

1893

SIR HIRAM MAXIM'S STEAM-DRIVEN AEROPLANE

WHIRLING ARM, TESTING TRACK

1896

PILCHER GLIDER

MAJOR BADEN-POWELL'S GLIDER

Major B. Baden-Powell. Mr. Wilbur Wright
LE MANS, OCTOBER 8, 1908

Hon. C. S. Rolls. Mr. Wilbur Wright
LE MANS, OCTOBER 8, 1908

1908-1910

GROUP OF EARLY AVRO MACHINES

Ranging from the Biplane at Brooklands, 1908, and the 9 h.p. Triplane which flew at Lea Marshes, July, 1909, to the School Biplane at Brooklands, 1911.

Lent by Mr. C. G. Grey.

1908-1912

GROUP OF CODY BIPLANES

Ranging from the Biplane of 1908 to Winner of the Military Trials in 1912.

1909

These enlarged photographs represent the first all-English machine ever built. It was constructed by Messrs. Short Bros. of Rochester. This machine flew a circular mile in 1909 piloted by Mr. J. T. C. Moore-Brabazon, winning the *Daily Mail* £1,000 prize. It won later the British Empire Michelin Cup, flying 26 miles.

Presented to the Society by Lt.-Col. J. T. C. Moore-Brabazon.

1909–1911

GROUP OF HOWARD T. WRIGHT MACHINES

Ranging from the Avis Monoplane flown by the Hon. A. Boyle in 1909 to the Biplane flown by T. O. M. Sopwith in America in 1911.

Lent by Mr. W. O. Manning.

1909–1911

SHORT MACHINE AT EASTCHURCH

1910

MARTINSYDE MONOPLANE

(The little oil-bath)

1910

BLACKBURN MONOPLANE

1911

WALTON & EDWARDS MACHINE AT BROOKLANDS

and

COLLYER ENGLAND MACHINE AT SHOREHAM (ALVASTON ENGINE)

1910

GREGOIRE GYP MONOPLANE AT BROOKLANDS

and

1911

WEISS INHERENTLY STABLE MONOPLANE

1911

MOLESWORTH TRIPLANE

Lent by Mr. C. G. Grey.

1911

VALKYRIE MONOPLANE

1911–1912

THE DUNNE INHERENTLY STABLE MACHINES

The Monoplane 1911 made successful flights at Eastchurch. The Biplane was awarded the official certificate for automatic stability by the Royal Aero Club, 1912, and flew from Eastchurch to Paris, 1913.

1911–1912

JEZZI BIPLANES

1912

HANDLEY PAGE INHERENTLY STABLE MONOPLANE

1912

AEROPLANES AT HENDON

Lent by Mr. C. G. Grey.

60 H.P. GREEN ENGINE

Winner of the Alexander Prize for the best British-built engine in 1912. It made two non-stop runs of twelve hours, developing a mean of 61.6 h.p. Bore 140 m.m. Stroke 146 m.m. Weight 301.9 lbs. Normal R.P.M. 1150.

1912

BRISTOL MACHINES AT SALISBURY PLAIN

1912

COVENTRY ORDNANCE BIPLANE

(Military trials)

Lent by Mr. W. O. Manning.

1912

GNOSSPELIUS HYDROPLANE AT WINDERMERE

Lent by Mr. C. G. Grey.

L. Howard-Flanders Ltd., Richmond

AIRCRAFT WORKS, 1912

SUPERMARINE, SOUTHAMPTON

1912–1913

FLANDERS MONOPLANE & BIPLANE

Lent by Mr. B. M. Dodds.

1912–1914

FLYING AT BROOKLANDS

1912–1914

FLYING AT HENDON

Lent by Mr. C. G. Grey.

1913

MANN AND GRIMMER MACHINE AT HENDON

and

SEAPLANE AT FELIXSTOWE, 1914

1913

GROUP OF SEAPLANES

1914

HANDLEY PAGE INHERENTLY STABLE BIPLANE AT BATH

1915

DYOTT MACHINE

JUNE 14–15, 1919

VICKERS VIMY LEAVING ST. JOHN'S, NEWFOUNDLAND, TO CROSS THE ATLANTIC

Sir John Alcock, pilot. Sir Arthur Whitten Brown, navigator.

and

THE FIRST VICKERS TWIN-ENGINE BIPLANE

Pictures and Engravings.

On another section of the panelled walls were displayed a large number of framed engravings, coloured aquatints, portraits, posters, etc., of the Early Ballooning Days. Practically the whole of these framed prints form part of the collection of Mr. J. E. Hodgson, and they attracted considerable attention, not only on account of their interest and rarity, but because of their remarkably fine state of preservation.

POLITICAL BALLOONING CARICATURES

CARICATURES OF STEAM FLYING MACHINES, ETC.

PORTRAIT OF JAMES SADLER OF OXFORD
THE FIRST ENGLISH BALLOONIST
BORN 1753—DIED 1828

RARE PORTRAITS OF VINCENT LUNARDI (1759-1806)

FIRST EXPERIMENT WITH A HYDROGEN BALLOON BY MONSIEUR CHARLES
CHAMP DE MARS, PARIS,
AUGUST 27, 1783

DESCENT OF THE FIRST HYDROGEN BALLOON AT GONESSE, 10 MILES AWAY, AUGUST 27, 1783

PILÂTRE DE ROZIER'S FIRST FREE ASCENT IN A HOT-AIR BALLOON FROM PARIS, NOVEMBER 21, 1783
THE WORLD'S FIRST AERIAL VOYAGE

PORTRAITS OF PILÂTRE DE ROZIER
THE WORLD'S FIRST AERONAUT

FIRST BALLOON EXPERIMENT IN LONDON AT THE ARTILLERY GROUND, MOORFIELDS
NOVEMBER 25, 1783

THE FIRST ASCENT OF MONSIEUR CHARLES IN A HYDROGEN BALLOON
PARIS, DECEMBER 1, 1783
THE WORLD'S FIRST ASCENT OF A HYDROGEN BALLOON

LANDING OF M. CHARLES AT NESLE
A FLIGHT OF 27 MILES FROM PARIS
DECEMBER 1, 1783

RETURN OF M. CHARLES' BALLOON TO PARIS, DECEMBER 2, 1783

ASCENT OF MONTGOLFIER AND PILATRE DE ROZIER WITH FIVE PASSENGERS
LYONS, JANUARY 19, 1784

ASCENT OF ANDREANI'S HOT-AIR BALLOON NEAR MILAN
FEBRUARY 25, 1784
FIRST BALLOON ASCENT IN ITALY

POISSON AEROSTATIQUE, OR BALLOON FISH ASCENDED FROM PLAZENTIA, SPAIN, MARCH 10, 1784

ASCENT OF THE BALLOON "LE SUFFREN" FROM NANTES
JUNE 14, 1784

FIRST AND SECOND ELONGATED BALLOONS OF THE BROTHERS ROBERT
JULY & SEPTEMBER 1784
FIRST FRENCH ATTEMPTS TO CONSTRUCT DIRIGIBLES

VINCENT LUNARDI'S BALLOON ASCENT FROM THE ARTILLERY GROUND, LONDON
THE FIRST ASCENT IN ENGLAND,
SEPTEMBER 15, 1784

LUNARDI'S GRAND AIR BALLOON AS IT ASCENDED FROM THE ARTILLERY GROUND, SEPTEMBER 15, 1784

KEEGAN'S ENGLISH HOT-AIR BALLOON
DESTROYED BY FIRE, PORTLAND PLACE, LONDON
SEPTEMBER 29, 1784

THE BURNING OF KEEGAN'S ENGLISH BALLOON IN LORD FOLEY'S GARDEN, PORTLAND PLACE, LONDON
A SATIRICAL ENGRAVING AFTER PAUL SANDBY

MARTYN'S AEROSTATIC GLOBE
EARLY BRITISH DESIGN FOR A DIRIGIBLE, OCTOBER, 1784

THE FIRST ASCENT OF BLANCHARD IN ENGLAND FROM LITTLE CHELSEA, LONDON, OCTOBER 16, 1784

PORTRAIT OF CHARLES GREEN (1785-1870)
THE FAMOUS VICTORIAN BALLOONIST
MADE OVER 500 AERIAL VOYAGES

PORTRAIT OF CHARLES GREEN (1785-1870) WITH VISITING CARD AND AUTOGRAPH

BLANCHARD AND DR. JEFFRIES ASCENDING FROM DOVER
THE FIRST CHANNEL CROSSING BY AIR, JANUARY 7, 1785

BLANCHARD AND DR. JEFFRIES OVER THE FRENCH COAST AFTER CROSSING THE CHANNEL, JANUARY 7, 1785

FIRST CHANNEL CROSSING BY AIR
BLANCHARD'S BALLOON LEAVING
DOVER CASTLE, JANUARY 7, 1785

ASCENT OF COUNT ZAMBECCARI'S
BALLOON FROM TOTTENHAM COURT
ROAD, MARCH 23, 1785

CARICATURE OF VINCENT LUNARDI'S
SECOND BALLOON ASCENT, MAY, 1785

LUNARDI'S SECOND GRAND AIR BAL-
LOON ASCENDED FROM THE
ARTILLERY GROUND, LONDON
MAY 13, 1785

VINCENT LUNARDI'S NEW BALLOON

PORTRAIT OF DR. POTAIN AND HIS
BALLOON
FIRST ATTEMPT TO CROSS THE
IRISH CHANNEL, DUBLIN,
JUNE 17, 1785

VINCENT LUNARDI'S NEW BALLOON
IN WHICH MRS. SAGE AND G. BIGGIN
ASCENDED, JUNE 25, 1785

THE THREE FAVOURITE AERIAL
TRAVELLERS
BEING THE SECOND STATE OF THE
ABOVE PRINT

CARICATURE OF LUNARDI'S
BALLOONING VENTURES, 1785

MAJOR MONEY'S ASCENT FROM
NORWICH
HIS PERILOUS SITUATION IN THE
SEA OFF YARMOUTH, JULY 23, 1785

THE PROVIDENTIAL ESCAPE OF
MAJOR MONEY
RESCUED FROM THE SEA AFTER 5
HOURS, JULY 23, 1785

FOURTH ASCENT OF MONSIEUR
BLANCHARD FROM LILLE,
AUGUST 26, 1785

BLANCHARD'S RETURN TO LILLE
AFTER THE ABOVE FLIGHT
AUGUST 26, 1785

BLANCHARD'S TWENTY-EIGHTH BAL-
LOON ASCENT FROM NUREMBERG,
NOVEMBER 12, 1787

BALLOON ASCENT AT THE BATTLE OF
FLEURUS, JUNE, 1794
FIRST AERIAL RECONNAISSANCE IN
WARFARE

PORTRAIT OF EDWARD SPENCER
(Born 1799)
FOUNDER OF THE WELL-KNOWN
FAMILY OF BALLOONISTS AND
AERONAUTS

1802
GARNERIN'S PARACHUTE DROP
OVER GEOSVENOR SQUARE

GARNERIN'S DESCENT IN A
PARACHUTE
FIRST PARACHUTE DESCENT MADE
IN ENGLAND, GROSVENOR SQUARE,
SEPTEMBER 12, 1802

JACQUES GARNERIN'S PARACHUTE
DESCENT, NORTH AUDLEY STREET,
SEPTEMBER 21, 1802
THE FIRST SUCCESSFUL DESCENT
IN ENGLAND

PARACHUTE DESCENT OF ELISA
GARNERIN

CHILD'S WRITING-SHEET WITH VARI-
OUS TYPES OF BALLOONS, 1802

FLIGHT OF DECORATIVE BALLOONS
AT THE CORONATION OF NAPOLEON,
PARIS, DECEMBER 3, 1804

JACOB DEGEN'S WINGED FLYING
MACHINE, VIENNA, 1807

BALLOONING CARICATURES IN THE
DAYS OF SADLER AND GREEN

CARICATURES OF SADLER'S BALLOON
ASCENTS AT HACKNEY AND OXFORD

JAMES SADLER'S THIRD ASCENT AT
OXFORD FROM MERTON FIELDS,
JULY 7, 1810

SADLER AND CLAYFIELD'S ASCENT
FROM BRISTOL
THEIR PERILOUS POSITION IN THE
BRISTOL CHANNEL,
SEPTEMBER 24, 1810

JAMES SADLER'S BALLOON ASCENT
FROM THE MERMAID TAVERN,
HACKNEY, AUGUST 12, 1811

JAMES SADLER'S BALLOON ASCENT
FROM THE MERMAID TAVERN, WITH
CAPT. PAGET, R.N., AUGUST 12, 1811

TWO ENGRAVINGS OF SADLER'S
ASCENT FROM HACKNEY, AUGUST 12,
1811

SADLER'S BALLOON ASCENT FROM
DUBLIN ON HIS ATTEMPT TO CROSS
THE IRISH CHANNEL, OCTOBER 1, 1812

SADLER'S ATTEMPT TO CROSS THE
IRISH CHANNEL
HIS RESCUE FROM THE SEA
OCTOBER 1, 1812

JAMES SADLER'S ASCENT FROM
NOTTINGHAM, NOVEMBER 1, 1813

JOHN SADLER'S ASCENT FROM ST.
JAMES' PARK, AUGUST 1, 1814

ASCENT OF JOHN SADLER'S BALLOON
FROM ST. JAMES' PARK,
AUGUST 1, 1814

PAULY AND EGG'S DOLPHIN BALLOON AND CARICATURE OF THE SAME, 1818

GEORGE GRAHAM'S BALLOON ASCENT FROM WHITE CONDUIT GARDENS, LONDON, SEPTEMBER 12, 1823

DISASTROUS DESCENT OF THOMAS HARRIS AT BEDDINGTON, CROYDON, MAY 25, 1824
FIRST FATAL ACCIDENT TO AN ENGLISH PILOT

CRUIKSHANK'S CARICATURE ON BALLOONING. A SKIT ON BALLOON PROJECTS, 1825

CORNILLOT'S BALLOON ASCENT FROM SEAL, NR. SEVENOAKS, KENT AUGUST 23, 1825

MRS. GRAHAM'S BALLOON ASCENT WITH TWO LADY PASSENGERS, MERMAID GARDENS, HACKNEY, AUGUST 9, 1827

POSTERS OF BALLOON ASCENTS BY CHAS. GREEN

EQUESTRIAN ASCENT OF CHARLES GREEN FROM WHITE CONDUIT GARDENS, LONDON, AUGUST 13, 1828

BROADSIDE
OPENING OF LONDON BRIDGE, AUGUST 1, 1831
CHAS. GREEN'S BALLOON ASCENDING

GREEN'S BALLOON ASCENT AT THE OPENING OF THE NEW LONDON BRIDGE, AUGUST 1, 1831

CHARLES GREEN'S 100th BALLOON ASCENT FROM THE MERMAID TAVERN, HACKNEY, MAY 14, 1832

GRAHAM'S ASCENT FROM NEW HUNGERFORD MARKET ON THE THAMES, JULY 2, 1833

VAUXHALL ROYAL BALLOON ASCENDING WITH TWENTY-EIGHT PASSENGERS, VAUXHALL, SEPTEMBER 9, 1836

GREEN'S FAMOUS ROYAL VAUXHALL BALLOON FIRST ASCENDED FROM VAUXHALL GARDENS ON SEPTEMBER 9, 1836

ROYAL VAUXHALL BALLOON ASCENDED FROM VAUXHALL WITH 20 PASSENGERS, SEPTEMBER 21, 1836

GREEN'S ROYAL VAUXHALL (OR NASSAU) BALLOON IN THE CLOUDS OVER THE MEDWAY, KENT

CONSULTATION BETWEEN HOLLOND, GREEN, AND MONCK MASON PRIOR TO THE FIRST OVERSEA VOYAGE TO WEILBURG, NOVEMBER 7, 1836

GREEN'S ROYAL VAUXHALL BALLOON CROSSING THE RHINE, NR. COBLENZ, NOVEMBER 8, 1836

THE VAUXHALL OR NASSAU BALLOON CROSSING THE ENGLISH CHANNEL AND OVER THE RHINE, NOVEMBER, 1836

PROSPECTUS OF THE AERONAUTIC ASSOCIATION FOR GEOGRAPHICAL SURVEYS IN UNEXPLORED AFRICA, THE FIRST PROJECTED AERIAL SURVEY CO., 1837

BALLOON POSTERS ANNOUNCING MRS. GRAHAM'S ASCENTS, SURREY ZOOLOGICAL GARDENS, 1837

ROBERT COCKING'S CONE-SHAPED PARACHUTE BENEATH THE ROYAL NASSAU BALLOON, JULY 24, 1837

ROYAL NASSAU (FORMERLY VAUXHALL) BALLOON ASCENDING WITH COCKING'S PARACHUTE, VAUXHALL GARDENS, JULY 24, 1837

ROBERT COCKING'S PARACHUTE ASCENDING BENEATH THE NASSAU BALLOON, AND THE FATAL DESCENT

ROBERT COCKING AND HIS PARACHUTE ASCENDING BENEATH THE NASSAU BALLOON, VAUXHALL GARDENS, JULY 24, 1837

PORTRAIT OF ROBERT COCKING KILLED IN A PARACHUTE ACCIDENT, JULY 24, 1837

THE FATAL CATASTROPHE TO COCKING'S PARACHUTE AT LEE, NEAR LEWISHAM, JULY 24, 1837

MUZIO MUZZI'S DIRIGIBLE BALLOON, BOLOGNA, 1838

HOAR'S GREAT MONTGOLFIER OR FIRE BALLOON
THE LARGEST EVER MADE IN ENGLAND
SURREY ZOOLOGICAL GARDENS, MAY 24, 1838

THE GREAT ATMOSPHERIC SHIP! A DESCRIPTIVE BROADSIDE OF HENSON'S AERIAL STEAM CARRIAGE, 1843

IMAGINARY VIEW OF HENSON'S FIRST CARRIAGE, "THE ARIEL"
THE EARLIEST DESIGN FOR A POWER DRIVEN SCREW-PROPELLED MONOPLANE, MARCH, 1843

IMAGINARY PICTURES OF HENSON'S "ARIEL" FLYING OVER THE PYRAMIDS AND OVER LONDON, 1843

MILLER'S ORNITHOPTER FLYING MACHINE, APRIL, 1843

VIEW OF EPSOM RACES AS SEEN FROM THE AIR IN 1846

ACCIDENT TO MR. AND MRS. GRAHAM'S BALLOON ON COL. NORTH'S HOUSE, ARLINGTON STREET, PICCADILLY, JUNE 16, 1851

POSTER DESCRIBING BALLOON ACCIDENT TO LIEUT. CHAMBERS AT CHARLTON, JULY 13, 1851

GEORGE GRAHAM'S DIRIGIBLE BALLOON, 1852

KIGHT'S BALLOON ASCENT AT CALCUTTA, 1853

ORIGINAL DRAWING OF AN EARLY ASCENT IN INDIA

PATERNOSTER'S FIRST ASCENT IN THE SULTAN, VAUXHALL GARDENS, AUGUST 7, 1854

HENRY COXWELL'S ASCENT IN THE MAMMOTH BALLOON WITH TEN PASSENGERS, CRYSTAL PALACE, SYDENHAM, SEPTEMBER 1, 1862

CARICATURES OF LENNOX'S "EAGLE" AIRSHIP AND THE BATTLE OF THE BALLOONS

STAND No. 231

On this stand were exhibited in two cases a number of interesting relics.

MODEL OF AVIS MONOPLANE

The Hon. A. Boyle flew this machine at Brooklands, 1910.

Lent by Hon. A. Boyle.

AEROFOIL, 1894

Actual aerofoil constructed in 1894 tested at Gottingen in 1913 and certified as giving lift/drag ratio —17, when best previously tested there or elsewhere —15.

Lent by F. W. Lanchester, F.R.S., Hon.F.R.Ae.S.

GLIDER, 1894

Out of some five or six made to same design and flown at Olton, Warwickshire, in 1894.

Note.—High aspect ratio and "wash out" of camber of aerofoil. Also two vertical fins to give lateral and directional stability.

Lent by F. W. Lanchester, F.R.S., Hon.F.R.Ae.S.

ROE 1907 BIPLANE

One of the four wheels made and used by A. V. Roe (now Sir Alliott Roe) on his biplane in 1907–8.

Lent by Sir Alliott V. Roe.

ROE 1907 BIPLANE

One of the wing-tip protectors made and used by A. V. Roe (now Sir Alliott Roe) on his biplane in 1907–8.

Lent by Sir Alliott V. Roe.

PORTION OF MAIN SPAR OF PILCHER'S GLIDER "THE HAWK"

Lent by H. Lloyd.

1862

COXWELL'S BALLOON GRAPNEL

Portable grapnel, with detachable flukes, used by Coxwell in the high altitude ascents he made in the "Mammoth" Balloon. (See the large engraving on the wall of the "Mammoth" ascending from the Crystal Palace with ten passengers).

Lent by Spencer Bros., Ltd.

1785

FIRST BALLOON ASCENT IN ITALY

Made from Moncucco, near Milan, February 25, 1784. The Balloon (inflated by means of fire carried in a grate) was skilfully constructed by the brothers Gerli, who published an account of their achievement in this fine book, printed at Parma in 1785 by the famous Italian printer, Bodoni.

Lent by Mr. J. E. Hodgson.

1794

EARLY PORTUGUESE TREATISE ON BALLOONS

The earliest Balloon ascents in Spain and Portugal were made by Vincent Lunardi from Madrid and Lisbon in 1792-94.

Lent by Mr. J. E. Hodgson.

INVENTIONS SECTION

STANDS No. 232—233

On these stands were displayed a number of interesting patents which had not yet reached the commercial stage of development, though holding out great possibilities.

1. A Spring Hub for Obviating Torsional Resonance in Aircraft Engines. Exhibited by Major B. C. Carter, F.R.Ae.S.
2. A Wooden Wheel for Aircraft. Exhibited by N. Comper, A.F.R.Ae.S. A light wooden wheel of novel construction.

3. The Arens Control Unit. Exhibited by L. H. Freeman. A form of construction for use where any push-pull control is required.
4. An Improvement in the Design of Ornithopters. Exhibited by C. F. Hodson. A method of constructing an ornithopter so that the moments about the wing hinges are balanced when the wings are not being flapped.
5. Model of an Expanding Annular Aerofoil. Exhibited by J. R. Porter.
6. Model showing a Means for Facilitating the landing of Aircraft by Night. Exhibited by J. Campbell Hart.

A part of the Inventions' Section.

7. Model Aeroplane showing an Instructive Safety Diagonal Control for Heavier-than-air Craft. Exhibited by J. G. Navarro, A.M.I.Ae.E., and Mary A. Navarro.
8. Model of a Rotor Plane. Exhibited by W. Scotter.
9. Audible Stall Warning Device. Exhibited by E. D. Wynn. A device on the principle of a syren, actuated when machine is about to stall.
10. Model of a Pump Applicable to Supercharging. Exhibited by Mr. McEvoy.

11. Model of Safety Fuel Tank. Exhibited by Captain F. L. M. Boothby, C.B.E., F.R.Ae.S. Made of balloon fabric containing another tank of goldbeaters skin. Capacity 16 gallons, weight 8 lbs.
12. Model of an Air Torpedo. Exhibited by Captain F. L. M. Boothby.
13. A Stall Warning Device. Exhibited by J. Barros. The device worked through the ordinary head telephones, giving audible warning as the stall was approached.
14. Rotating Vane and Eccentric Drum Type Pumps. Exhibited by E. Lanzerotti-Spina, R.I.N.C., A.F.R.Ae.S.

ITALIAN SECTION

STANDS No. 224—225

Model of the Grocco-Genecchie canard flying boat fitted with lateral fins and small hydroplane wings. 1911.

General Guidoni's cantilever flying boat, second model. 1913. (Wind channel model.)

The first experimental apparatus for testing free hinge and variable pitch air propellers.

Photo of the 80/100 h.p. C.R. second hydroplane in flight (skimming) on the Lake of Bracciano (Rome) at a speed of 44 m.p.h. (1907). The full-size machine was on view at the Science Museum.

General Guidoni's cantilever flying boat. First model, 1912. (Wind channel model.)

Device for measuring the lift and propulsive force of a helicopter, carried out by Messrs. Grocco and Costanzi.

Stern of the rigid airship Project with Grocco's elastic rudders. 1913-1914.

Cross section of the Italian rigid airship Project with steel tube tower, carrying at the top an aerial 1in. gun and at the base a 15in. torpedo launching tube. 1913-1914.

Photographs of Leonardo da Vinci's sketches of flapping wing models, soaring flight models, and a portrait of Leonardo da Vinci.

Six lifting screws of equal surface, but with different number of blades. (Studies of the helicopter carried out by Messrs. Grocco and Costanzi. 1911.)

Imaginative painting of Leonardo da Vinci's proposed machine in flight.

Free hinge propeller blade for M-type semi-rigid airship. 1911.

Uncovered propeller blade for M-type semi-rigid airship. 1911.

Hinge propeller blades for M-type semi-rigid airship. 1917.

Reduction gear of the four-blade propeller for M-type semi-rigid airship with control for varying the pitch. 1911.

Variable pitch four-blade propeller hub for M-type semi-rigid airship. 1911.

Grocco's route indicator. 1916.

Model of Enrico Forlanini's hydroplane, 1904. This machine was constructed in order to study, besides nautical facilities, the possibility of rising from the water.

The first idea of static lift. Model of Francesco Lana's aerial ship, suspended by means of four hollow copper balls emptied of air. 1670.

Original aeroplane model of Enrico Forlanini taking off by means of a gunpowder tube along two steel wires and flying up to 600 feet in 20-25 seconds. 1885.

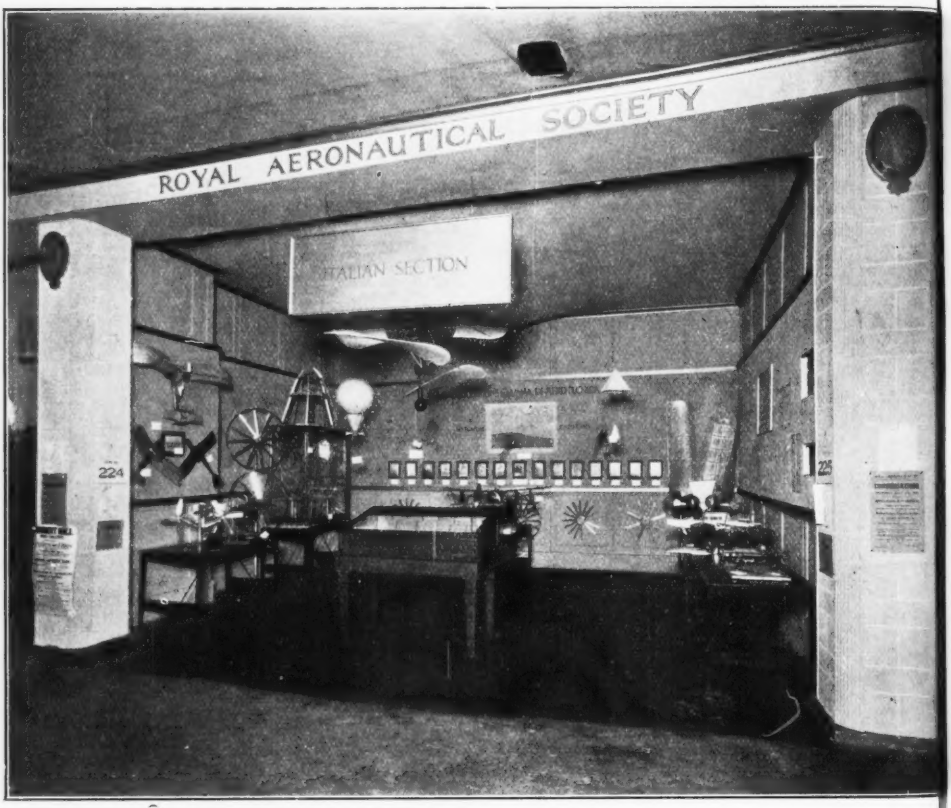
Lateral stability problem solved independently from the Wright Brothers. Reconstruction of Grocco's variable incidence wing aeroplane model with manual control for lateral stability. 1903.

Grocco apparatus for deriving the shape of cross section of airship envelope. 1914.

Model of the machine of the greatest Italian aeronaut—Count Francesco Zambeccari. The machine consisted of a balloon filled with hydrogen and a bag filled with heated air. 1803.

Three models of Leonardo da Vinci apparatus.

The Grocco Guidoni telebomb. This biplane type telebomb, when released from the aeroplane, dives through the air until the speed attained is sufficient for a gliding flight. A gyroscope controls the direction rudder during the gliding



The Italian Section.

of the bomb towards the target. A screw which is previously set to the required number of turns works at the proper time a device which, through the elevator, causes the bomb to fall on the target.

Leonardo da Vinci's parachute. 1486-1490.

The first helicopter with engine to leave the ground. The Enrico Forlanini helicopter, driven by a steam engine, rose from the ground on June 29th, 1877, reaching the height of 40 feet.

Agreement for the Constitution of a Society for Promoting Count Zambeccari's Flights. (Manuscript.) 1803.

The Aerial Ascent of Count Andreani in Milan. 1784. (Booklet.)

Monthly Journal of the Italian Aerotechnical Society.

Programme for the Constitution of a Society for Promoting Count Zambeccari's Flights. 1803. (Pamphlet.)
Il Giornale Aerostatico. The first aeronautical magazine in the world, printed in Milan in 1784.
Report of the aerial journey of Count Zambeccari with two companions from Bologna to Pola in Dalmatia. 1803. (Manuscript.)
Boffito's Biblioteca Aeronautica Italiana, 1929.

FRENCH SECTION

STAND No. 226

Collection du General Hirschauer.

Journal des Scavan of December 13th, 1678, giving an account and plates of the flying experiments of Besnier. First scientific account of a flight.
Two engravings of Blanchard's machine.
Lead plates commemorative of the crossing, taken from an inn near Calais, of Blanchard and Jeffries after their first Channel aerial crossing.
Marble tablet commemorating the construction of the first hydrogen balloon. 27-8-1783.
Three small engravings of gas balloons.
Coloured engraving of a hot-air balloon.
Collection de l'Aero Club de France. Engravings of the inhabitants of Gossene mistaking the first Montgolfier balloon for a monster and attacking it with pitchforks, guns, stones, clubs, etc.
Eight engravings of Montgolfier balloons.
Portrait of M. Montgolfier.
Five engravings of MM. Charles and Robert's gas balloon.
Engraving of " Le Petit Maitre Physicien " in balloon clothing.

Show Case containing Collection of Paul Tissandier.

Balloon embroidered on silk part of lady's dress. 1784.
Three fans with balloons.
Eighteen engravings of balloons.
Price list of toy balloons.

Collection Charles Dollfus.

Sixteen engravings of balloons.
Engraving, portrait of Blanchard. 1753.
Engraving, map of flights of M. Charles near Paris.
Portrait (drawing) of Pilâtre de Rozier, the first man to leave the ground. (By Pujos.) 1783.

Collection du General Hirschauer.

(Engraving) The Flesselles hot-air balloon, the largest free balloon ever built and flown. Volume 800,000 ft. 1784.
(Engraving) Balloon crash. Passengers being removed from the basket.
Three engravings of gas balloons.
Engraving of balloon on fire in the air.
Engraving of tomb of Pilâtre de Rozier and of Romain.

Collection Andre Pupier.

First navigable balloon of the Brothers Robert. 1784.

Collection Charles Dollfus.

First drawing of a balloon ascent (Blanchard at Lille, 1785).
Three engravings of gas balloons.
Two engravings of gas balloons in warfare. Land, sea.
Engraving of a balloon guided by horses and ropes.
Engraving (coloured). Fashions in clothes and Montgolfier balloon.

Collection Andre Pupier.

(Engraving) Ascent of Mme. Jaques Garnerin, first female pilot.
Engraving, portrait of Mme. Jaques Garnerin, first female pilot.
Engraving, schemes for attack of England. Balloons, ships, tunnel.
Three engravings of parachutes.
Three engravings of balloons.
Gnome engine. 1909.

CASE I.

Collection Charles Dollfus.

Three fans with balloon designs.
Three covers of books with balloon designs.
Sword with balloon engraved on hilt.

Collection Paul Tissandier.

Seven snuff boxes with balloons.
Coloured picture of balloons.
Knife handle bearing balloon design.

CASE II.

Musée de l'Aeronautique.

Pottery plates of Nevers, Strasbourg. 1783. 1784.

Collection Charles Dollfus.

Aerostatique. 1785. With engraved copper plate (Montgolfier balloon).
Seven pottery plates with balloon design.
Printed fabric (cretonne) with Charles' balloon. 1783.
Small miniature (framed) with Charles' balloon. 1783.

Collection Paul Tissandier.

Tin plate engraved in Germany to commemorate the first aerial Channel crossing by Blanchard.

CASE III.

Collection Charles Dollfus.

Draft of a handbill written in English by Garnerin.
Catalogue with prices of the auction of Garnerin's physical instruments in London. 1815.
Letter of recommendation given to Garnerin by the Prince of Wales for his ascent of July 5th, 1802. On the back is the certificate of landing.
Certificate of landing of Garnerin, written and delivered by Sir J. C. Hippisley.
Autograph draft of a handbill for a London theatre by Garnerin. 1814.
Letter of the Secretary of the Duke of York to Garnerin.
Autograph letter of Garnerin to his passenger Sowden after a failure that the latter sustained. 1802.

Autograph sketch of Louis Bleriot, giving the map of the first aeroplane Channel crossing, July 25th, 1909.
Autograph drawing of a wing by Ader—a study for the first aeroplane which made a free but not sustained flight. 1890.
Autograph sketch of Clement Ader on his experiment with the "Avion," October 22nd, 1897.
Original patent drawings of Penaud and Gauchot project of amphibian aeroplane. 1876.

The French Section.

Penaud and Gauchot aeroplane, patent comprising nearly all of the devices now in use on aeroplanes, seaplanes and amphibians. It is one of the most interesting projects issued in the 19th Century.
Antoinette engine, 1904, 24 h.p. First motor especially made for aviation in France by Levavasseur.

Collection Charles Dollfus.

Coloured print (historical) with balloon in background.
A children's game with balloon ornamentation.
A coloured plan of grounds at Nuremburg with balloon in background.

Carmien de Luz dirigible. No date.
Portrait of M. and Mme. Blanchard.
Engraving of Blanchard's balloon.
Coloured print of pear-shaped balloon with flapping wings.
(Engraving) " Passage du Roi sur le Pont Neuf lors de son entrée a Paris le 3 Mai, 1814." (Balloon in background.)
(Coloured engraving) " Fête du sacre et couronnement de Leurs Majestés Impériales." 1804.
(Engraving of balloon) " Systeme d'Helle."
(Coloured print) " Balloons (pièce sur les) Fête au Champ de Mars." This shows parachute descent from balloon, a tight-rope walker, a pony race, a walking race, apparatus for filling the balloon, climbing the greasy pole, helter-skelter.
Two prints of Mme. Garnerin making a parachute descent at Berlin, 1829.
Coloured print of airship. 1837.
Portrait of Arban—first aeronaut to cross the Alps in a balloon. 1849.
Illustration of Le Précurseur, a very modern looking non-rigid, built but not tested by Juillien. 1851.
Le Jeune Guerin, age de 13 ans, caught by the grapnel of a balloon set free, 16th July, 1643.
Engravings and oil painting of balloons.
Antoinette engine, 24 h.p., 1904. First aviation engine.

SHOW CASE.

Collection Charles Dollfus.

Five book covers, children's tales, with balloons for ornamentation.
One handkerchief (coloured) with Petin's navigable balloons. 1851.

BOOKS.

L'Art de Naviger dans les Airs by Galien. 1755. (The rarest French book on aeronautics.)
French translation of Bishop Wilkins' " World in the Moon." Published 1666.
" Histories Prodigieuses," by Belleforest. 1581. Giving an account of the terror inspired in the Parisians by a kite.
Almanack for 1781 with the smallest engraving of a balloon made in France at this time.
Pigeon post film used in Siege of Paris. Sixteen pages of printing reproduced on a film about 2in. by $1\frac{1}{4}$in.
The earliest photograph of an aircraft—model airship of Vert at Paris. 1859.
Portrait of Dupuis Delcourt.

SHOW CASE.

Collection Charles Dollfus.

Pamphlet of Dupuis Delcourt, 1857, in favour of the creation of an Aeronautical Museum.
(Pamphlet) Lettre a Monsieur le President De xxx sur Le Globe Aeronautique sur les Fêtes parlantes, et sur l'état present de l'opinion à Paris. 1783.
(Book) Questions Inouyes, by Mersenne. 1634. A book which inspired the Bishop Wilkins to write on air navigation and submarine boats.

CENTRE CASES.

A.

Giffard's steam airship, Paris, Sept. 24th, 1852. This airship was *the first* to be experimented in full size with a steam engine and *the first* to make turns under the action of its propeller and rudder, Henry Giffard being the pilot.

B.

Experimental helicopter of Ponton d'Amecourt, 1863. This original steam helicopter was the first mechanical piece of work built of aluminium. It was exhibited under No. 6 at the Aeronautical Exhibition of 1868 in the Crystal Palace.

C.

Airship La France, scale 1/50, Renaud and Krebbs, 1884. The airship La France is the first aircraft in the world to have performed a controlled circuit, starting and landing at Chalais Meudon on August 9th, 1884. The original electric motor is exhibited.

D.

Hydrogen balloon of Charles and Robert, Paris, Dec. 1st, 1783. This hydrogen balloon was the first which was successfully flown (by Charles and Robert) from Paris to Nesles, Dec. 1st, 1783. It includes all the principles of the free balloon.

E.

Bleriot's cross-Channel aeroplane. 1909. Scale 1/10.

Original helicopter of Alphonse Penaud. 1870-1875.

Tatin's original experimental aeroplane flown in 1879. Victor Tatin's aeroplane with two tractor airscrews and a compressed air motor was tried at Chalais Meudon in 1879, and made flights, being guided in a circle by a string.

Electric engine of the airship La France. 1884. This electric motor, made by Krebs, received current from batteries made by Renaud. It was used on the airship for its successful ascents of 1884. It developed 8 h.p. and weighed 200 lbs.

Model Fabre seaplane. First to take off from the water, 1910. Scale 1/10. The Henri Fabre tripod monoplane, mounted on floats, experimented by its inventor, is the first seaplane having actually taken off from the water and made flights, March, 1910.

Model Santos Dumont aeroplane, the first to fly officially in Europe, 1906. Scale 1/10. The engine was an Antoinette.

Deperdussin aeroplane, 1913. The first to fly at a speed over 200 k.p.l. (130 m.p.h.). Scale 1/10.

Antoinette Levavasseur cantilever monoplane. 1911. Scale 1/10. This Antoinette Levavasseur monoplane, which made two short flights in 1911, included many modern aerodynamical improvements—thick cantilever wing, landing gear, etc.

Montgolfière of Pilâtre de Rozier, the first to carry men in the air, 1783. This hot-air balloon of 80,000 cu. ft., made by Etienne Montgolfier was *the first* to carry a man in the atmosphere (captive ascent of Pilâtre de Rozier, Oct. 13th, 1783), and the first to navigate the air with two men on board (Pilâtre and d'Arlandes), Paris, Nov. 21st, 1783.

F.

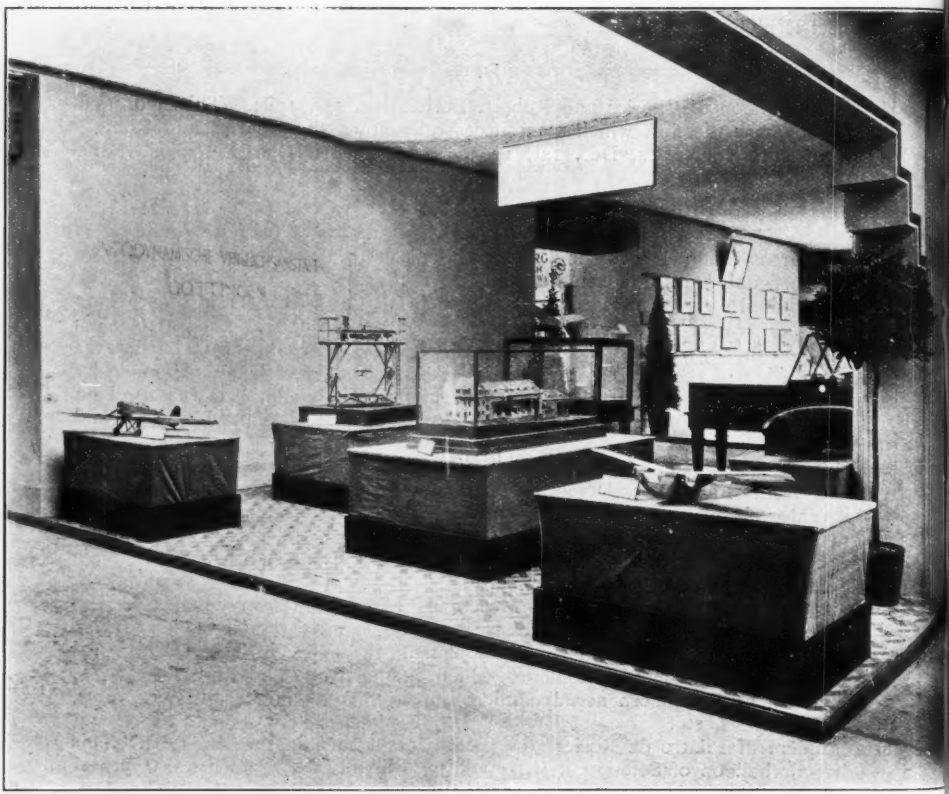
Garnerin's parachute, Paris, Oct. 22nd, 1797. This parachute is the first with which a man, Jacques Garnerin, descended from a balloon 3,000 feet high in the Parc de Monceau, Paris, Oct. 22nd, 1797.

Model of Oehmichen's helicopter which performed a flight, in a triangular circuit, of one kilometre, with its inventor as pilot. The machine was tried in 1923-24.

GERMAN SECTION

STANDS No. 228—229

Photographs of test tank and aeroplane floats under test; dynamometer, etc., for measurement of forces on models in tank; apparatus for producing model hulls for testing in tank.



The German Section.

SHOW CASES.

CASE I.

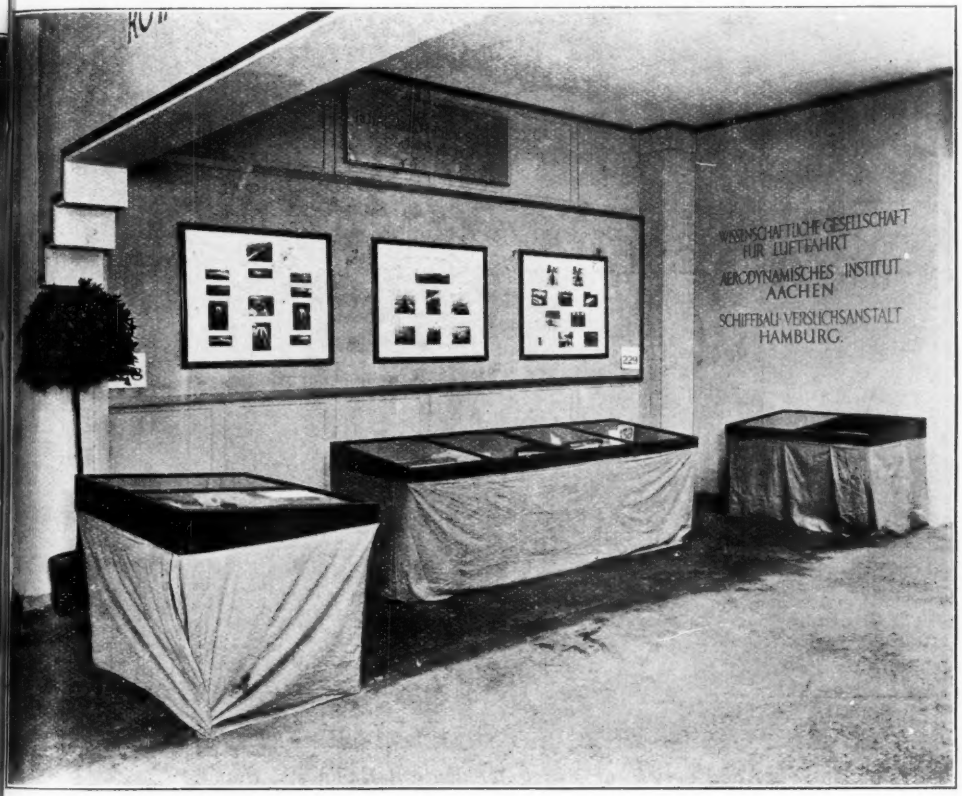
Photographs of the apparatus at the Technical High School at Aachen—School of Aerodynamics. These photographs included illustrations of throat of large wind channel (Eiffel type), various apparatus for compressed air and water towers, photographs of exterior of institute, testing machines, a fuselage under test for vibration test and elasticity test.

CASE II.

Periodicals and books; portraits; medals; photograph of Lilienthal's tomb; and the Lilienthal medal.

CASE III.

Photograph of Göttingen Aerodynamic Institute, and technical publications.
Models for wind channel tests. Junkers aeroplane type A.35 with propeller driving electric motor.



The German Section.

Model of balance used at Göttingen.
Part-sectioned model of Göttingen wind channel building (Eiffel type).

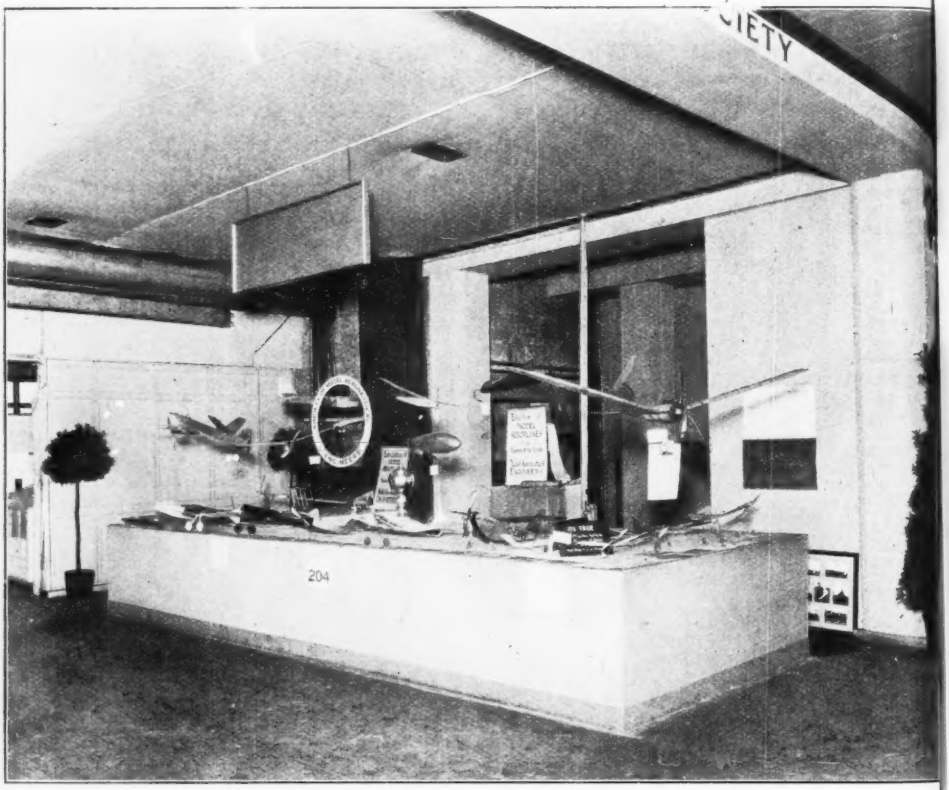
MODEL SECTION.

Copper model of airship envelope.
Wind channel model of Rohrbach passenger aeroplane "Roland."

THE SOCIETY OF MODEL AERONAUTICAL ENGINEERS

STAND NO. 204

Under the ægis of the Royal Aeronautical Society, the Society of Model Aeronautical Engineers showed a large number of flying models. A history of the Model Aeronautical Engineers was given in the illustrated Souvenir Booklet published during the Exhibition, together with a list of the models which were shown.



The Society of Model Aeronautical Engineers' Stand.

AERONAUTICAL FILMS

Exhibited in the Cinema Hall, Olympia, under the ægis of the Royal Aeronautical Society and The Air League of the British Empire

During the course of the International Aero Exhibition, the Royal Aeronautical Society and the Air League of the British Empire made arrangements for the showing of aeronautical films every day. The films proved to be a most attractive addition to the Exhibition, and the Air Ministry and many private firms contributed to make the Cinema Exhibition a success. The Council wish

to place on record their thanks for the great assistance which was rendered by those mentioned as lending the films shown below.

Title.	*Loaned by*
The Heart of an Aeroplane	D. Napier and Son, Ltd.
First tests of "Ripon II." Torpedoplane. Demonstration of a number of types during summer of 1928, and part of Kiel's Cup Race of 1928, showing arrival and departure of "Lincock" ...	The Blackburn Aeroplane and Motor Co., Ltd.
Tests and demonstration flights of "Iris I." and "Iris II."	" "
Sir Alan Cobham's African Survey Flight in the "Singapore." Trial flight and start from Rochester	Short Bros., Ltd.
"Calcutta" under construction. Film taken in Erecting Shop	" " "
Launch and trial flight of "Calcutta"	" " "
Sir Samuel Hoare's flight in the "Calcutta" at Rochester	" " "
"Calcutta" at Westminster	" " "
The Bristol Jupiter Aero Engine	Bristol Aeroplane Co., Ltd.
Gaumont Film taken on occasion of Christening at their works of a Westland "Wapiti" machine for Australia	Westland Aircraft Works.
Catapulting on U.S. "West Virginia"	Fairey Aviation Co., Ltd.
"Fremantle" at Hamble	" " "
U.S. Aircraft Carrier "Langley"	" " "
"Schneider Trophy," 1926 No. 1	" " "
" " " No. 2	" " "
R.A.F. Pageant, 1927	" " "
General News. Trial Film only	" " "
Pulford at Cape, 1926	" " "
III.D. Dutch in water. ¾ view	" " "
" " " side	" " "
" " " coming across	" " "
" " " past left quay	" " "
Sky-writing. (3 films)	Major J. C. Savage, Savage Sky-writing Co.
Landing a long-distance aeroplane at Cranwell ...	Air Ministry.
Jaguar, Assembling and Dismantling	" "
King Amanullah	" "
Theory of Flight:—	
Part I. Streamline.	
" II. Lift and Lift-Drag Ratio.	
" III. Stalling.	
" IV. Stability.	" "
(Un-named)	W. G. Armstrong-Whitworth Aircraft Co., Ltd.
Aerial Views of Mont Blanc and Alps, Spring of 1928	Mr. H. Beamish.
Record Flight of Major Vicherek	J. Walter and Co.
" " Captain Hamsik	" " "
"Aviation"	Dept. of Commerce, U.S.A.
Aeroplane in a Flat Spin	The Hon. Wm. P. MacCracken, Junr.
Military School at Istres	Messrs. Morane-Saulnier.
Film (un-named) on Manufacture of "Farman" aeroplanes	Messrs. H. & M. Farman.
Tirs et Bombardements—IIeme Regiment d'Aviation de Metz	M. Louis Breguet.
IIeme Regiment d'Aviation de Metz—hydravion Breguet XIX.	" " "
"La Vie Aeronautique de L. Bleriot"	M. Louis Bleriot.
Catapulting Installation on the S.S. "Bremen" ...	Messrs. Ernst Heinkel.
Aus der Arbeit der Bayerischen Flugzeugwerke A.G.	Messrs. Bayeriche Flugzeugwerke A.G.
"Junkers Aircraft all over the World"	Messrs. Junkers-Flugzeugwerke A.G.
"Rohrbach-Roland"	Messrs. Rohrbach-Metall-Flugzeugbau.
"Rohrbach-Romar"	" "
"Rohrbach-Rostra"	" "
Various films concerning latest aeroplanes	Sr. Ing. G. Caproni.

CORRESPONDENCE

The Secretary,
Royal Aeronautical Society,
7, Albemarle Street, London, W.1.

July 17th, 1929.

SIR,—Some further torsiograph observations have been made on the Tornado III. engine since Wing Commander T. R. Cave-Browne-Cave read his paper, entitled "The Machinery Installation of Airship R.101," and the following information on the matter is communicated in response to your esteemed invitation.*

In his contribution to the discussion of the paper (published in the March issue of the Journal), Professor Haigh has explained the apparent anomaly of "administering a sedative with one hand and at the same time a stimulant with the other." There was, however, a further consideration, namely, that the step taken in stiffening the shaft might in itself suffice if, for any reason, the fitting of the elastic coupling should prove to be inexpedient. Moreover, the stiffening of the shaft does not involve an appreciable increase in the coupling flexibility required to bring the fourth order major critical speed down to the desired value.

The dynamic system corresponding to the Tornado III. engine is shown in Fig. 1, which shows also the relation between the fourth order (major) critical speed and the flexibility of the connection of the crankshaft flange to the airscrew mass. It will be noted that the points corresponding to experimental observations with spring hubs of different flexibilities of connection are reasonably close to the theoretical values—which were calculated from an estimated crankshaft stiffness value and upon the assumption that the airscrew is absolutely stiff in the plane of rotation. The effect of flexibility of the airscrew in its plane of rotation, and of imperfect frictional grip, is to reduce the critical speeds.

Two "elastic curves" or "amplitude graphs" are shown, one corresponding to a rigid connection, and the other corresponding to an elastic connection having a stiffness of 5.2 million pounds inches per radian.

It will be seen with the spring hub drive there is no steep run in the amplitude graph. With the rigid drive, however, the slope of the amplitude graph changes rapidly along the crankshaft, the node being located between the crankshaft flange and the first throw.

Theory indicates that in an eight-cylinder in line engine having the firing order that obtains for the Tornado engine, the $5\frac{1}{2}$ order minor critical single node vibration may possibly be troublesome. This critical occurs at 4/5.5 times the fourth order (major) critical speed, and thus, if the latter is at 1,100 r.p.m., the former is at 800 r.p.m.

Fig. 2 shows some torsiograms taken with a wooden airscrew directly attached to the crankshaft. It is clearly indicated that the fourth and $5\frac{1}{2}$ order vibrations have maximum amplitude at the speeds mentioned. Eighth and twelfth order (major) critical vibration is revealed at appropriate speeds, *i.e.*, at one half and near one third of 1,100 respectively. The $6\frac{1}{2}$ order minor critical is indicated at 650 r.p.m. which is near to 4/6.5 times 1,100 r.p.m.

* Published by permission of the Director of Research, Air Ministry.

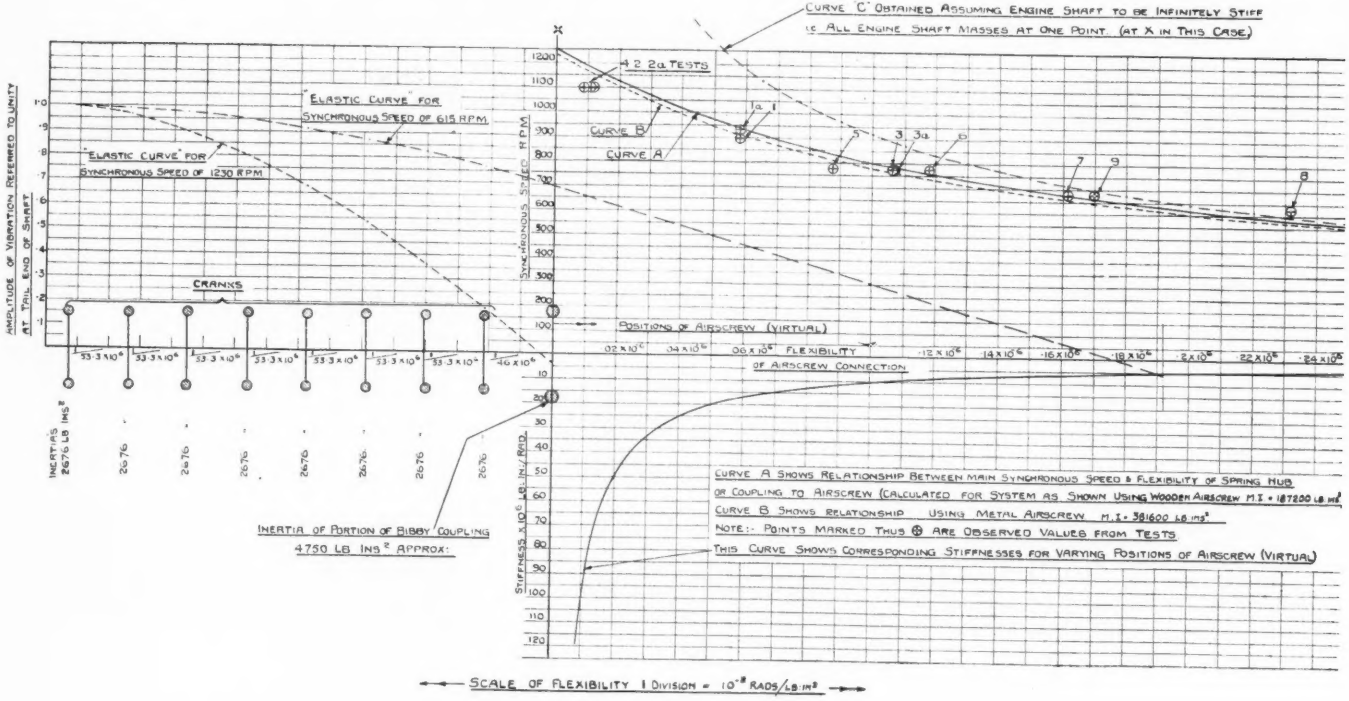

CURVE 'C' OBTAINED ASSUMING ENGINE SHAFT TO BE INFINITELY STIFF
I.E. ALL ENGINE SHAFT MASSES AT ONE POINT. (AT X IN THIS CASE)
AMPLITUDE OF VIBRATION REFERRED TO UNITY AT 'TAIL' END OF SHAFT
"ELASTIC CURVE" FOR SYNCHRONOUS SPEED OF 615 R.P.M.
"ELASTIC CURVE" FOR SYNCHRONOUS SPEED OF 1230 R.P.M.
CRANKS
4.2.2a TESTS
CURVE B
CURVE A
SYNCHRONOUS SPEED R.P.M.
POSITIONS OF AIRSCREW (VIRTUAL)
FLEXIBILITY OF AIRSCREW CONNECTION
INERTIAS 2676 LB INS²
INERTIA OF PORTION OF BIBBY COUPLING 4750 LB INS² APPROX:
STIFFNESS x 10⁶ LB-IN./RAD.
CURVE A SHOWS RELATIONSHIP BETWEEN MAIN SYNCHRONOUS SPEED & FLEXIBILITY OF SPRING HUB OR COUPLING TO AIRSCREW (CALCULATED FOR SYSTEM AS SHOWN USING WOODEN AIRSCREW M.I. = 187200 LB INS²
CURVE B SHOWS RELATIONSHIP USING METAL AIRSCREW M.I. = 381600 LB.INS²
NOTE:- POINTS MARKED THUS ⊕ ARE OBSERVED VALUES FROM TESTS
THIS CURVE SHOWS CORRESPONDING STIFFNESSES FOR VARYING POSITIONS OF AIRSCREW (VIRTUAL)
SCALE OF FLEXIBILITY 1 DIVISION = 10⁻⁸ RADS/LB.INS²

FIG. 1.

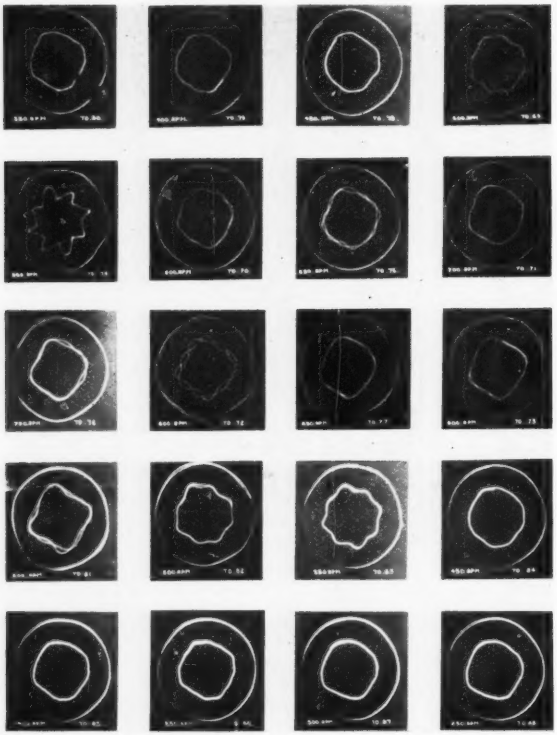


FIG. 2.

Torsiograms for an eight-cylinder in line engine with a direct driven wooden airscrew.

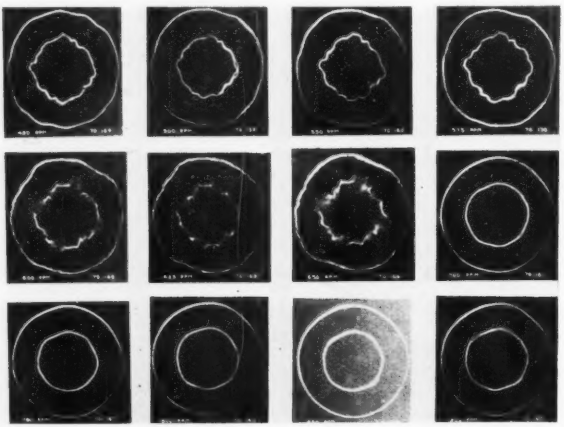


FIG. 3.

Torsiograms for the same engine (see Fig. 2) but with a special spring hub.

Fig. 3 shows some torsiograms taken with a spring hub fitted of 4.3 million pounds inches per radian stiffness. The fourth order (major) critical is in the region of 625 r.p.m. and the torque variation is small at all running speeds above 650 r.p.m. It may be mentioned that with the hub stiffness in question the engine runs remarkably smoothly in this speed region.

At speeds well above the fourth order (major) critical, the torque variation in the drive is less than the variation of the combined cylinder impulses—the reason being that the crank masses function as an oscillating flywheel having an

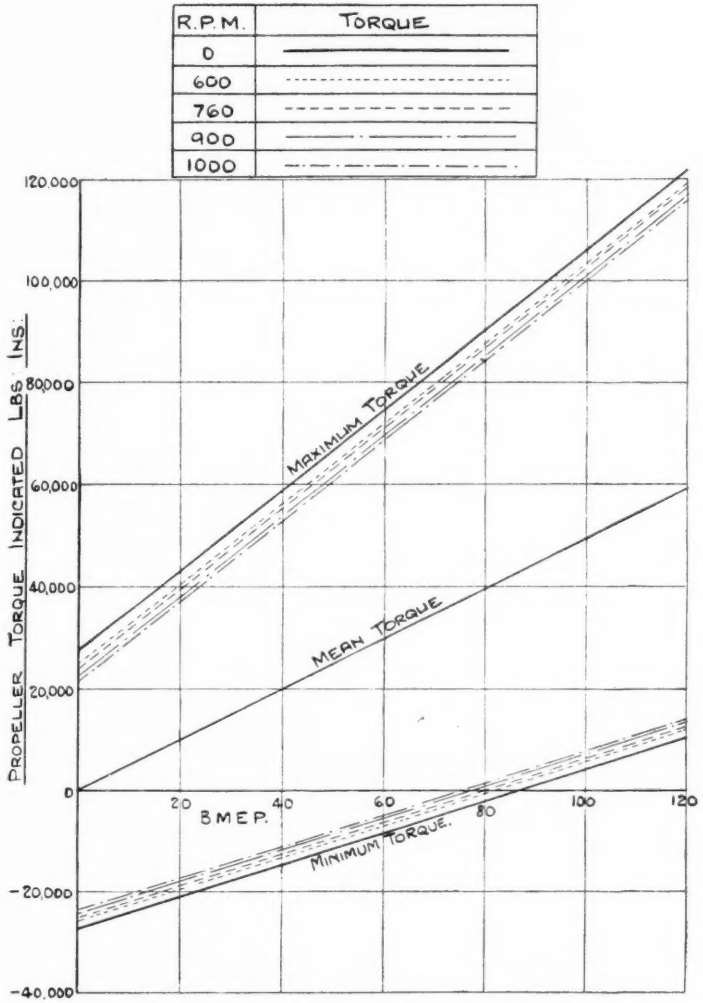


FIG. 4.

Tornado (indicated) propeller torques due to gas forces only at various brake mean effective pressures, also including inertia forces.

amplitude of swing which is too small to produce much variation in the airscrew driving torque. This condition is not only favourable to the engine, but also to the airscrew.

As regards the variation of the combined cylinder impulses, the value given by Wing Commander Cave, namely, 75 per cent. of the mean, is an underestimate, and was given to him by myself without the opportunity of referring to the Tornado torque curves. The variation is given in Fig. 4, for different brake mean effective pressures and speeds. The influence of speed is relatively small. The reduction of torque variation with reduction of B.M.E.P. (with full throttle opening) is much less than for a corresponding petrol engine—owing to the difference of compression ratio.

To reduce the variation at low B.M.E.P.s, and to obtain improved low speed running, air intake throttles have been fitted, and it was by using such that it was possible to get steady running down to 250 r.p.m., to obtain the low speed torsiograms of Fig. 2.

The test results substantiate the importance of avoiding dynamic conditions which bring about serious amplification of the explosion impulses, and indicate the advantage to be gained by lowering the main synchronous speed to a low speed low throttle region—a matter concerning which there has been some controversy.

They also constitute additional evidence that the simplifying assumptions which are made for the purpose of theoretical treatment are satisfactory in respect of high speed engines.

In conclusion, I should like to express my indebtedness to my colleagues at the R.A.E. who have taken part in the tests partially described above, and in particular to Mr. N. S. Muir, B.Sc.

Yours faithfully,

B. C. CARTER.

REVIEWS

Aeroplanes, Seaplanes and Aero Engines

Captain P. H. Sumner. London, 1929. 25/- net.

Captain P. H. Sumner is well-known for his book on Airships and Balloons, and this new production deals with heavier-than-air craft. The book covers a very wide field in less than 300 pages, much of the space of which is taken up by some 250 illustrations. To cover the field adequately in such a space is not possible. The book is only an outline of the subject, indeed, a preliminary stepping stone to those who wish to obtain an elementary grasp of aircraft and aircraft engines. Like all books of this nature which attempt a popular exposition together with the introduction of aerodynamical, design and other formulæ, the book falls between two stools. For the practical designer it is too elementary, and for the non-technical reader it contains formulæ which would be beyond his understanding. It is a mixture to be taken with care.

Airplane Stress Analysis

Alexander Klemin. New York, 1929. $7.

This is one of the Ronald Aeronautic series published by the Ronald Press Company of New York. Professor Klemin's name on the title page of a book is a sufficient guarantee that it will be authoritative. He is, of course, the professor of Aeronautical Engineering at the Daniel Guggenheim School of Aeronautics, New York University. The function of the book is to meet the growing need of University and other students in aeronautics to obtain a grasp of the principles of engineering as applied to aeroplane structures. The methods of stressing which are given follow the practice laid down by the Departments of Commerce, Army and Navy in the United States, and these methods differ in many essentials from British practice. Bearing this fact in mind, however, the book can be thoroughly recommended to the keen student and designer who wishes to have, within the covers of the book, not only the methods used in the United States for aeroplane design, but the corresponding data which is needed for reference.

The first two chapters cover the usual ground necessary in the theory of structures, the more accurate methods for solving various cases of combined bending and compression being given in an appendix. In chapter 3 the requirements of the Department of Commerce are stated, followed by three chapters on materials of construction, wires, cables and attachments.

The real value of Professor Klemin's book begins with chapter 7, the first of a series of chapters in logical order analysing the methods of stressing aircraft in very much the way that an actual analysis is carried out. Chapter 8 gives a sample wing analysis, following the principles laid down in the previous chapter, of a three-seater, semi-cantilever, single-engined monoplane. The succeeding chapters give, in detail, the methods of designing and calculating the stresses in the spars and struts, the chassis, fuselage and tail plane unit. The great value of these chapters lies in the worked-out examples.

To every embryo designer who wishes to obtain a clear insight of the methods used in the United States Professor Klemin's book is one which can be thoroughly recommended. It is one of the best of its kind, and one which cannot but be of help to every one concerned with the stressing of aeroplane structures.

The Third Route

Philip Sassoon. London, 1929. 15/-.

Sir Philip Sassoon has chosen a happy title for a record of his journey by air from London to India in the closing months of 1928. When Vasco de Gama in 1497 made his voyage round the Cape to India he opened a new trade route to the riches of the East. The vision of that great engineer, de Lesseps, resulting in the first sailing of a steamer through the Suez Canal in 1869, brought India nearer to Europe—the second Trade Route. The Third Route, the air route, was blazed by Ross Smith and Keith Smith, and their flight to Australia turned the thoughts of many airwards and Eastwards.

Sir Philip Sassoon will be numbered among the pioneers of the air Trade Route. " This is the story of the Third Route, which has already brought India within five days of London and will shortly be traversed backward and forward by a steady stream of traffic; until this Air Way to the East is as well known as and little less frequented than the Great North Road," to quote the opening paragraph of the book, in which the author describes in vivid phraseology his impressions of a tour of inspection along the route in the flying boat Iris.

The work is not only a record of the flight, and a very sound record, but is most delightfully written, written with all the naiveté of a schoolboy describing his first big thrill, and with that sense of scholarship and proportion given to few.

The air pioneer describes his flight from Greece to Heliopolis. " We arrived at Heliopolis after an hour's flight, just as the sun was setting behind the Pyramids in a sky of rose, blue, almond-green and lemon. We had seen the Parthenon and the Pyramids in one rosy day, and Naples the day before. How swift and many-coloured my journey had already become! In the whole of it I had but one serious disappointment. At breakfast at Athens I had looked forward confidently for honey from Hymettus, and they had bought me Keiller's marmalade."

In the course of his inspection the Nile was flown from Cairo to Khartoum and back, and many passages describe, unforgettably, the impressions of the air traveller.

" Next, on the very verge of the river which year by year is eating away the cliff on which it stands, we saw the temple of Kom Ombo. The Ptolemaic structure must ultimately go the way of the far earlier temples which preceded it. It is not so well preserved as the temple at Edfu, but is still an imposing mass of pillars and mighty roof stones. Here the ancient Egyptians worshipped the crocodile, fed it on butter and fresh fowls, and gave it ear-rings of green glass . . . . Whatever may be said about the temples, there is no doubt that the dam at Assuan gains immensely in impressiveness when viewed from an aeroplane. The colossal mass of masonry, a mile and a quarter in length, well stands comparison with the work of the Pharaohs, and the great blocks of which it is composed were hewn from quarries which the Pharaohs used. The sluices were open and had let loose their garnered floods upon the irrigated lands below, so Philæ was free from the watery shroud which envelops her during the greater part of the year, when the dam is full."

There is much of interest not only to those who ever contemplate travelling by means of the Third Route and who wish to have a most delightful guide book to their journey, but to those who are already air-minded. Here will be found much dealing with the units of the Royal Air Force Sir Philip inspected, and their work. During his air tour of inspection Sir Philip Sassoon was accompanied by Air Commodore A. M. Longmore, and the pilots were Flight-Lieut. L. Martin and Squadron-Leader C. L. Scott. The latter will be remembered for his account of the trip, from a more technical point of view, which he gave in a lecture before the Society. The lecture was published in the September issue of the Journal.

The Air Annual of the British Empire

734 pp. Gale and Polden, Ltd. 21s. net.

This is the first year of publication of a new Air Annual. It is founded and edited by Squadron Leader C. G. Burge, who, in his preface, states that it is intended to form a complete record, year by year, of progress in British aeronautics. The Air Annual of the British Empire justifies the claims which have been put forward for it, and it should become an aeronautical best seller. It is undoubtedly the best air annual which has yet been produced. It is more than a complete reference book. It is a book which fascinates and compels one to continue reading.

The Annual is divided into four main sections—Empire Aviation, Service Aviation, Civil Aviation and the British Aircraft Industry. In the first section appears a series of authoritative articles on the Empire and Air Communications, Aviation and the Empire, Empire Air Policy, Aircraft in Imperial Defence, The Development and Progress of Flying in the Dominions, Empire Airships, The Air League of the British Empire and The Royal Aeronautical Society.

The Service side is covered in the same way and in this section is given very fully the history, growth and organisation of the Royal Air Force and the Air Forces of the Dominions, and a mass of statistical information, from an analysis of the Air Estimates to a chronology of Service Aeronautics.

The section devoted to Civil Aviation, a section which will rapidly grow in importance, opens with an article by Professor A. W. Kirkaldy on the Development and Economics of Air Transport. The article is somewhat disappointing, especially in respect of its development of the theme "The Economics of Air Transport." A thorough survey of air economics by an authority outside the industry has yet, one believes, still to be written, and a dispassionate survey by such an authority would probably be of considerable assistance to the industry. The following article by F. E. Bray, a member of Lloyds, is an excellent summary of the position of Aviation Insurance, and is followed by a series of articles on Civil Aviation in the Dominions, Flying Clubs, Air Survey and Photography, and a reference section. This latter section could be improved by the addition of approximate times taken and costs on the most frequented air routes. Air travel publicity is not good, except the gratuitous publicity given by the newspapers for a "story" or accident. It should be as easy to buy an air ticket to Paris, say, as to buy one to Birmingham, but the man in the street is not yet *au fait* with the methods of obtaining such tickets. And when he does the restrictions make him no happier.

The section on the British Aircraft industry forms, as it should do, the greater part of the Annual. It begins with an excellent general survey by Captain P. D. Acland and follows with articles reviewing particular aspects of the industry, and a very complete series of articles on firms and their products, including the principal firms in the Dominions.

The Annual is lavishly illustrated. Its illustrations in fact in themselves are a remarkable record of the amazing progress which has been made in this country in the last twenty years.

Necessarily, as must be expected, the first attempt at anything is in the nature of an experiment, and there is always room for improvement. It appears to the reviewer that a short list of the more important publications of the year would be a useful addition in future Annuals. One is rather surprised to see no mention of the Autogiro, the Monospar form of construction, and the Redrup engine. The index is not a good one. It is divided into a number of parts, in itself irritating and unnecessary, and prefaced by the word Indices. The usual plural of a book index is indexes, the plural form indices of index being kept

for the mathematical use of the word. Under aero engine, air-cooled, one finds *see* air-cooled engines, and it is immediately followed by a dozen or so references which apparently refer to air-cooled engines, but are in reality references to aero engines in general. Under air-cooled engines are half a dozen references at the bottom of page 711. In the middle of the first column of page 712 one finds another batch of references to air-cooled engines.

These are only minor criticisms however. Squadron Leader Burge has produced, on the whole, an excellent reference volume, and the publishers are to be congratulated on its general make-up. It is a book which must be in constant use for all concerned with British aviation and one which should be in every reference library.